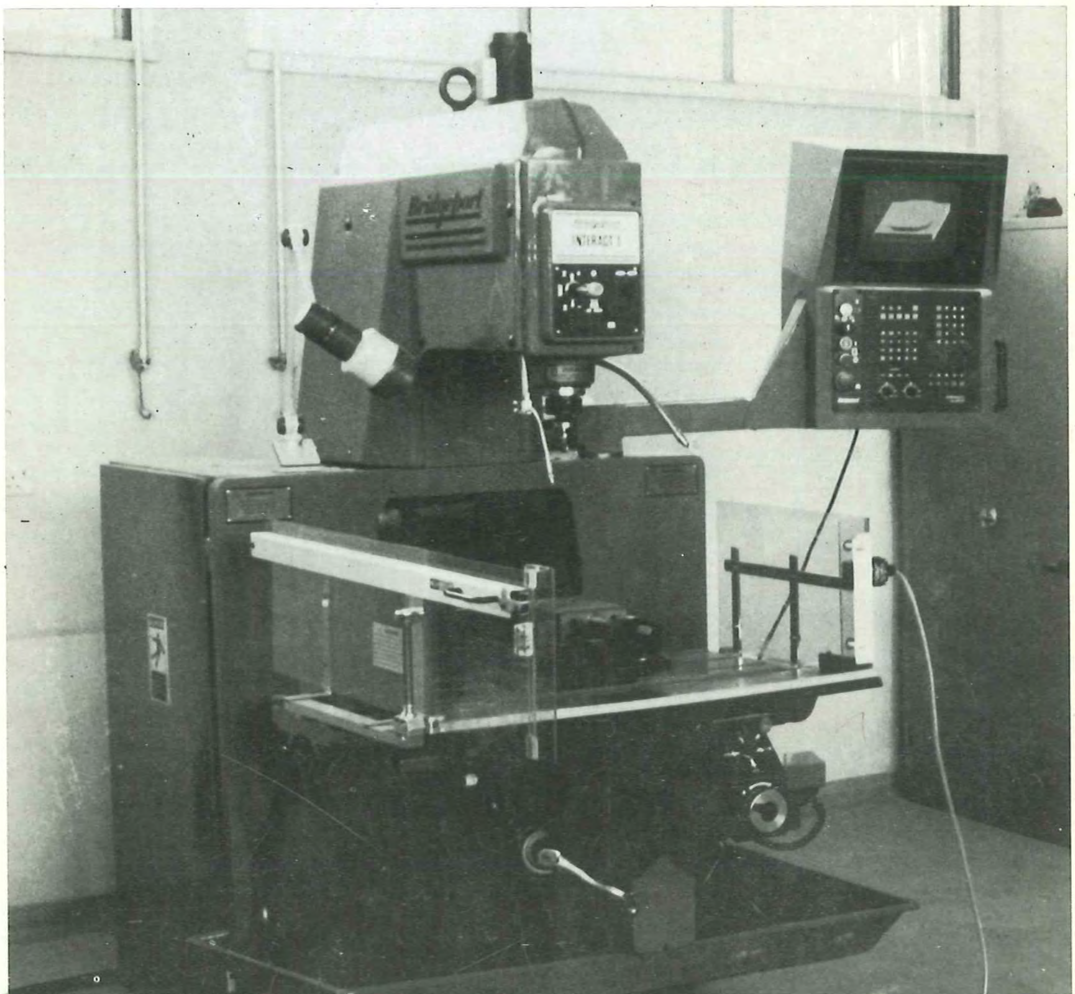
No. 19 June 1990 Nicosia Cyprus

Review

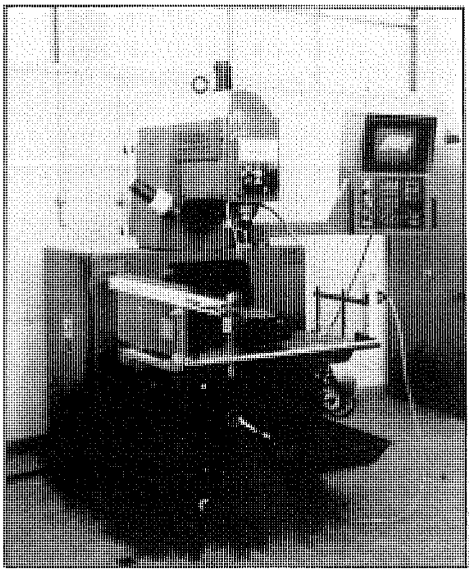
THE HIGHER TECHNICAL INSTITUTE



The Higher Technical Institute (HTI) was established in 1968 as a Government of Cyprus project with assistance by the United Nations Special Fund (UNDP), the United Nations-Educational Scientific and Cultural Organisation (UNESCO), and the International Labour Office (ILO). Cyprus Government Executing Agency: The Ministry of Labour and Social insurance.

Review

No. 19 June 1990 Nicosia Cyprus



Computer Numerically Controlled Milling Machine

Cover Photograph by HTI

HTI Review is published by the Press and Information Office in cooperation with the Higher Technical Institute, Nicosia. It accepts articles which promote and further new developments and knowledge in technology, especially with reference to Industries of Cyprus. Requests for further copies of the magazine and for information concerning the published articles should be made to Chief Editor HTI Review, Higher Technical Institute, P.O.Box 2423 - Nicosia, Cyprus. Tel. 02 494454 - 02 305030, Tlx 4070

P.I.O. 27/1990 — 500

CONTENTS

Page

Genetics-based machine learning

Christos Schizas, PhD Lecturer HTI
Kyproula Christodoulou, MSc Geneticist MDRTC
Costas Pattichis, MSc Visiting Lecturer HTI

This work has been sponsored by the Muscular Dystrophy Research Trust of Cyprus MDRTC

INTRODUCTION TO MACHINE LEARNING

Automatic performance improvement with experience can be accepted as a rough-and-ready definition of learning. This implies a yardstic for measuring performance: if one cannot evaluate a system's performance, nothing can be said about learning. In practical terms learning algorithms aim the achievement of certain measurable goals such as providing more accurate solutions. It can also be suggested that machine learning is the key to machine intelligence just as human learning is the key to human intelligence.

The object of a learning system, natural or artificial, is the expansion of its knowledge in the face of uncertainty. The performance of a learning system is improved by generalising upon past experience.

Machine learning is potentially applicable to a number of different tasks(1), such as:

Automatic programming: the object is for the computer to develop its own programs. Automatic programming is very difficult since we expect our programs to give the right answers under all conditions.

Creativity: learning and creativity are strongly interelated, in that creativity is learning something for the first time ever. Learning, in people, is often a creative act; one may think he has done something original, but it is not called creativity because perhaps someone else has already made the discovery. Learning in this case is creativity at second hand.

Data Compression: this is normally an unintended by-product of machine learning simply because the rules learned are typically much shorter than the training data, yet they can be used to reconstruct the important properties of that training data.

Knowledge synthesis: Designers of expert systems tend to think of machine learning in terms of synthesizing knowledge. For them it is a short-cut towards obtaining knowledge from a human expert; such knowledge has to be elicited, codified and checked by a "knowledge engineer".

Optimization: Machine learning can also be seen as a kind of optimization. This is particularly clear in parameter-adjustment systems where the knowledge is expressed as a linear function. The objective here is to find a set of parameters or coefficients.

Machine learning applications include: medical diagnosis, predicting earthquakes, game playing, image recognition, signature verification, weather forecasting, intelligent information retrieval.

Learning can be achieved in a number of ways (2). To date one can identify four major machine learning paradigms and multiple sub-paradigms under investigation:

1. **Inductive learning,** which is based on acquiring concepts from sets of positive and negative experiences.
2. **Analytical learning,** a more recent but very widely studied paradigm for learning, an explanation-based learning that also uses certain forms of analogical and case-based learning methods.
3. **Connectionist learning methods,** which are also called "neural networks" or "parallel distributed systems" (3,4). Neural Networks are presented with training sets of representative cases or classes, that they learn to recognize and classify accordingly. Learning is achieved through adjustment of weights in a fixed-topology network via different learning algorithms such as the back propagation training algorithm (4,5) for supervised learning and the Kohonen algorithms for unsupervised learning (6), and
4. **Genetic algorithms learning** which are also known as "classifier systems".

The above mentioned machine learning paradigms emerge from quite different scientific roots, employ different computational methods, and often rely on subtly different ways of evaluating success, although all share the common goal of building machines that can learn.

The main purpose of this article is to examine one of the above learning methods, the genetic paradigm, and show how the laws of nature can be used for classifying very complex but "natural" events.

INTRODUCTION TO GENETICS

Genetic science, through the study of heredity, has elucidated many of the mechanisms of nature that enable the transmission of characteristics from parents to offspring (7). The hereditary units are called *genes* and it is their interaction with one another and with the environment that results in the production of distinctive characteristics. Genes are coded by *DNA* (deoxyribonucleic acid) which is folded around a family of proteins called histones, forming the chromosomes. Chromosomes are enclosed into the cell nucleus and their number is characteristic for each species. The human genome is composed of 23 pairs of homologous chromosomes (fig. 1). Of the 46 chromosomes of an individual, 23 have derived from the mother and the other 23 (homologous) from the father.

During *reproduction* a male and a female gamete (*haploid* cells) come together to form the zygote (*diploid* cell), that will develop into the future offspring (8). A cell is called haploid when it carries only one set of the homologous chromosomes (ie. 23 chromosomes) and it is called diploid when it carries each type of chromosome twice (ie. 46 chromosomes).

Haploid cells are produced from diploid cells by a process called *meiosis*. During meiosis genetic *recombination* takes place, an important mechanism that enables exchange of information between homologous chromosomes. The two homologous chromosomes come together and form cross-shaped points of junction between them. At the points of *crossing-over* they are cut and joined to each other, exchanging homologous parts (fig. 2).

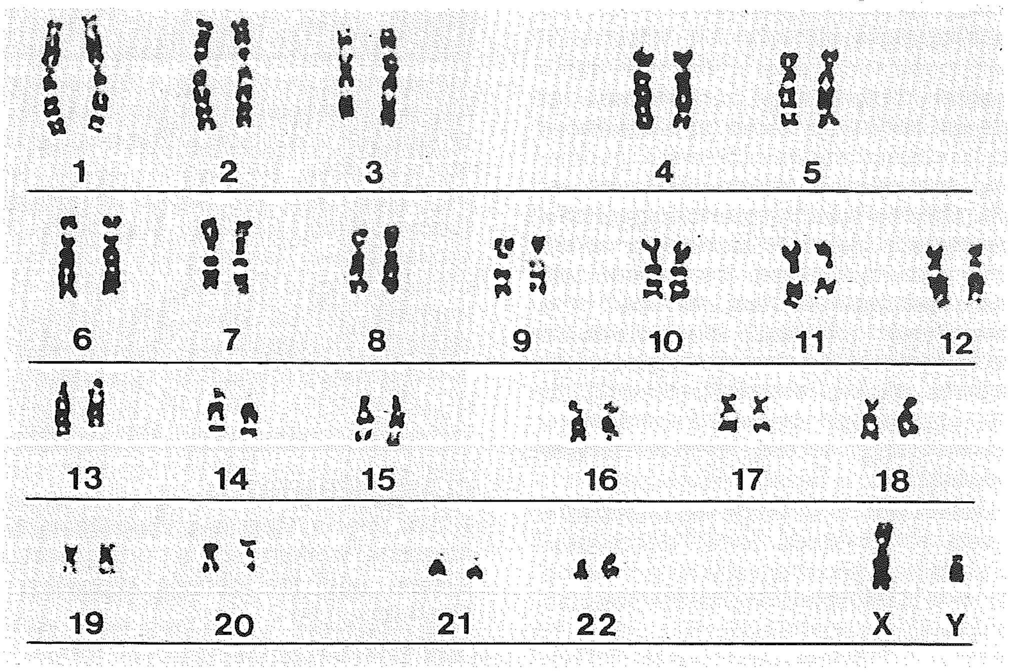


Fig. 1. Human Karyotype showing the 23 pairs of chromosomes

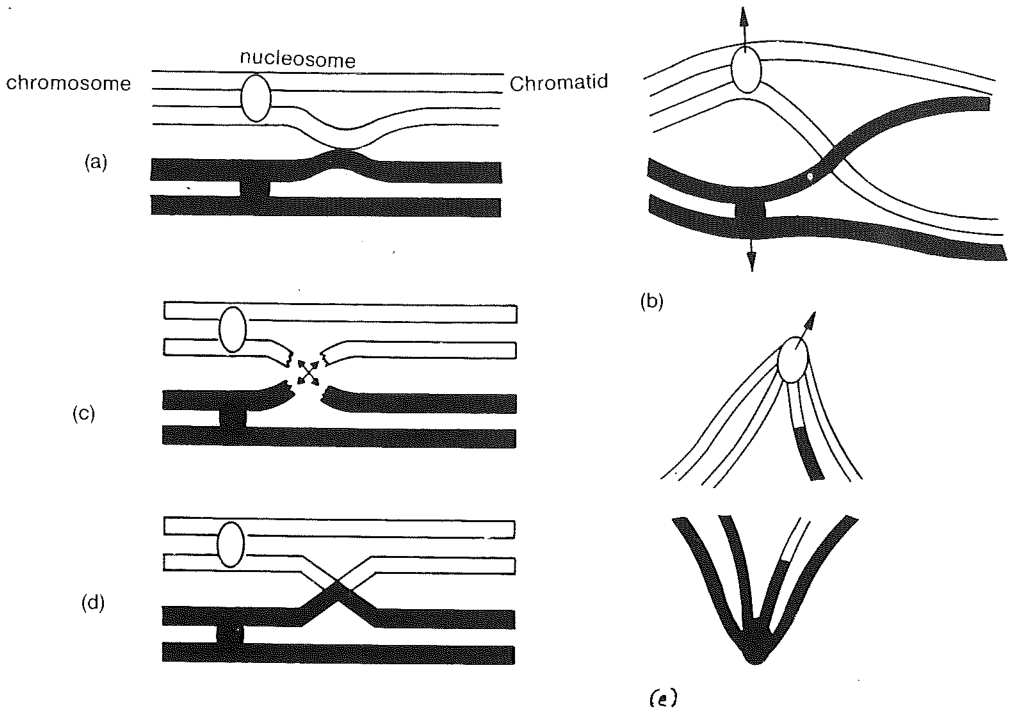


Fig.2 *Crossing over*
a. Homologous chromatids are attached to each other
b. Crossing over
c. Breakage
d. Reunion & exchange of pairing partners
e. Separation

The DNA sequence of genes coding for the same product is not necessarily the same between individuals. Changes can take place by *mutation*, a process that causes the replacement of a particular sequence by another or the deletion of part of the gene. A mutation could be neutral causing no alteration in the product of the gene. However, it could also cause a change in the product which would result in either a selective advantage or disadvantage of the mutated gene compared to the normal. The fate of the mutated gene through generations is determined by *selection*.

In a given population and under the same environmental factors the performance of individuals will not be the same (9). Differences are partially caused by the different genetic constitution and different reproduction rates of individuals. The reproductive performance of a certain genotype is called its *fitness* (Darwinian fitness). Fit individuals are those that will reproduce, thus contributing to the next generation. Weak (or less fit) individuals contribute very little to the next generation or do not contribute at all, therefore leading to extinction of the genotype. Furthermore genotypes with high fitness tend to survive through generations.

Nature has been very wise in the mechanisms it has evolved to produce new genotypes, exchange parts between them and select for the highly fit among them, searching for the possible best genotype.

GENETIC ALGORITHM

The above mentioned mechanisms of nature have been employed in the *Simple Genetic Algorithms* (10). The aim of Genetic Algorithms (GA) is optimization of data by the search for strings of best fit.

Any data under investigation is decoded to strings of finite length. The population of data strings is then subjected to the basic mechanisms of nature such as reproduction, crossing-over and mutation. For each string, a fitness value is generated based on an apportionment of credit algorithm. The bigger the fitness value the higher are the chances that the string will be selected for reproduction. Selected strings will contribute to the next generation of strings. They are pulled out of the whole population and are paired, according to their fitness value. Between the pairs of strings crossing-over takes place. The position of crossing over is allocated at random. At very rare intervals strings could also be subjected to mutation. The resulting population of new strings will then follow the same procedure, for a number of generations. The number of data strings remains constant through the generations.

CLASSIFIER SYSTEM

A classifier system is composed of a rule and message system, an apportionment of credit system and the genetic algorithm (11), as illustrated in fig 3.

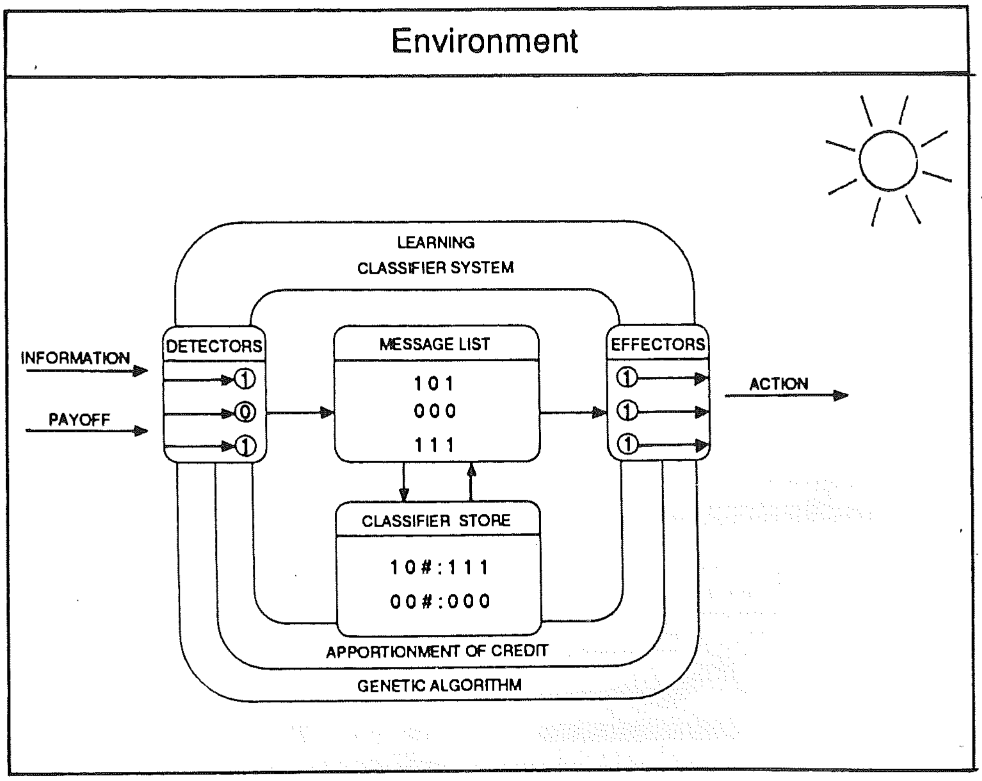


Fig. 3 *A learning classifier system showing the interaction of the rule and message system, the approtionment of credit algorithm and the genetic algorithm.*

Data is entered from the **environment** through the **detectors** and is decoded to finite length messages. Messages then pass through a message list where they may activate the classifiers. At the completion of the classification process the final optimized message passes through the **effectors** and the appropriate action returns to the **environment.**

Classifiers are strings of production rules which are defined by a condition and a message.

(classifier) is defined as (condition): (message)

The **message** of the **classifier** is a string of finite lenght *(n)* of a certain coding system, for example a number system. The **condition** of the **classifier** is a pattern recognition device with a wild card character added to the adopted coding system. With reference to the binary number system the message is composed of *n* codes which are either 0's or 1's. The product could be a string of the same length *n* as the message, but composed of 0's, 1's and the wild card symbol (#) which means that, at the specific part of the string the code could either be an 0 or 1. For example the classifier could be: 01 # 1:0010, where 01 # 1 is the condition and 0010 is the message. In the above example the condition would be matched both by the strings 0101 and 0111.

The bucket brigade (or apportionment of credit) algorithm is called after the condition of a classifier has been matched, to evaluate the classifier's worth. The main components of the algorithm include an activation auction and a clearinghouse. In order to participate in the auction the classifier should keep a record of its strength and make a bid proportional to its strength. Selected, for activation, classifiers must clear their payment through the clearinghouse by sending their bid to contributing classifiers. In simple words, the classifier responsible for sending a matching message gets credit, and the activated classifier loses credit. In general the bucket brigade algorithm is in charge of providing a fair distribution of credit among activated classifiers. The bucket brigade algorithm works until no more classifiers are activated by the messages and a reward is finally paid to the last active classifier.

As illustrated in fig 4 the initial strenght of classifiers was equal (200 units each); after a number of time steps the strength of classifiers has been altered in a manner that reflects the matching of the input data with the classifiers. The environmental message 0111 is posted to the classifier. A bid coefficient C_{BID} is assumed for all classifiers, the bid being the product of C_{BID} and the current strength of classifiers. At the initial step (t=0) the envirnomental message matches classifier 1 which bids 20 units to the environment and sends its message 0000 to the next time step (t=1). During this time step the message matches classifiers 2 and 4 which send messages 1100 and 0001 respectively, resulting in the reduction by 20 of their corresponding strengths. The bid values (total of 40) are used to pay classifier 1 for sending the matching message. The procedure continues until no matches exist. Finally, at step 5, a reward comes into the system and is paid to the last active classifier, classifier 4.

		$t = 0$				$t = 1$				$t = 2$			
Index	Classifier	Strength	Messages	Match	Bid	Strength	Messages	Match	Bid	Strength	Messages	Match	Bid
1)	0 1 # #:0000	200		*E*	20	180	0000			220			
2)	0 0 # 0:1100	200				200		1	20	180	1100		
3)	1 1 # #:1000	200				200				200		2	20
4)	# # 0 0:0001	200				200		1	20	180	0001	2	18
	Environment	0	0111			20				20			

		$t = 3$				$t = 4$				Final $t = 5$	Payoff
Index	Classifier	Strength	Messages	Match	Bid	Strength	Messages	Match	Bid	Strength	
1)	0 1 # #:0000	220				220				220	
2)	0 0 # 0:1100	218				208				208	
3)	1 1 # #:1000	180	1000			196				196	
4)	# # 0 0:0001	162	0001	3	16	156	0001			206	50
	Environment	20				20				20	

Note: 1. $C_{BID} = 0.1$
2. $C_{TAX} = 0.0$

Fig. 4 *A simple Classifier System by Hand Matching and Payments.*

The genetic algorithm (GA) is called at defined periods of rule and message cycles, to enable the introduction of new and possibly better rules into the system. The GA is called to work on a selected proportion of the population that will be replaced by the last GA generation of rules. Selection is based on the strength value of classifiers which is used as their fitness value during the operation of the Genetic Algorithm. It is concluded that the aim of the GAs is not to change the character of the "natural" data but to amplify some characteristic features through optimization.

This property of GAs makes them ideal tools for handling complex data in the areas of medical diagnosis (such a neurophysiology), engineering (such as VLSI design, adaptive filter design, job shop scheduling, aircraft landing optimization), biology (such as cell population simulation, investigation of niche theory), image processing and pattern recognition, social sciences, operations research etc.

Genetics-Based Machine Learning (GBML) as described in this article is currently investigated by our team as a tool for providing medical diagnosis. Data collected from clinical electromyography is very complex and impossible to be analysed by any classical statistical method. Our team has shown (4,5) that neural networks can produce very good results with acceptable diagnostic yields which fully agree with the clinical tests, carried out on the same subjects. We believe that GBML can be used as an alternative method to neural networks or even be used in combination with neural networks, in an attempt to provide a fully automated computer aided medical diagnosis.

In the last decade the fields of Biological and Computer Sciences have experienced an exponentially growing advancement and specialisation. Their impact in our nature based algorithms (GBML) is inevitable.

REFERENCES

1. R. Forsyth and R. Rada, *Machine Learning, Applications in expert systems and information retrieval*, Ellis Horwood Series, 1986.
2. J.G. Carbonell, *Introduction: Paradigms for Machine Learning*, Artificial Intelligence, 40, p 1-9.
3. C. Schizas, *Parallel Processing via Artificial Neural System*, HTI Review, Vol 18, 1989.
4. C. Schizas, C. Pattichis, I. Schofield, P. Fawcett and L. Middleton, *Artificial Neural Net Algorithms in Classifying Electromyographic Signals, First IEE Int. Conference of Artificial Neural Networks, Vol. 313, p 134-138, 1989.*
5. *C. Schizas, C. Pattichis, I. Schofield, P. Fawcett and L. Middleton, ANNS in Computer Aided Macro Motor Unit potential Classification*, Engineering in Medicine and Biology Magazine of the IEEE, Vol. 9, No. 3, 1990.
6. T. Kohonen, *Self-Organization and Associative Memory*, Springer-Verlag, 1987.
7. D. J. Weatherall, *2nd Edition, Oxford Medical Publications, 1985.*
8. *A. McDermott, Cytogenetics of Man and Other Animals* Otuline Studies in Biology, Chapman and Hall, 1975.
9. F. Vogel and A.G. Motulsky, *Human Genetics, problems and approaches* 2nd Edition, Springer-Vergal, Chapter 6, 1986.
10. D.E. Goldberg, *Genetic Algorithms in Search, Optimisation and Machine Learning* Addison-Wesly, Chapter 1, 1989.
11. L.B. Booker, D.E. Goldberg and J.H. Holland, *Artificial Intelligence*, 40, pp 235-282 "Classifier Systems and Genetic Algorithms".

" Our bodies do not need to become tired, sick, exhausted and old. Change your 'image' of yourself; see yourself well, of course observing and practicing all the rules of health, and you will tend to be that which you visualize and practice".

Dr. NORMAN VINCENT PEALE

" As the day wears to evening and evening deepens into night, can you look back over the waking hours and recall something you have said or done that was really worthwhile? You can? That's good. You can't? Why?

FRANCIS GAY

" Almost every man thinks too poorly of himself. He undervalues his brain and his will and his stamina. He has no idea of what he can do — if he dares".

HERBERT N. CASSON

A brief survey of image processing

Marios Prountzos, Andreas Athanasiades,
Final Year Students in Computer Studies, HTI

In memory of Christophoros Solomou

This work has been sponsored by the Muscular Dystrophy Research Trust of Cyprus

INTRODUCTION

Image processing is the science of modifying, and analyzing pictures. Image processing algorithms are step-by-step procedures for performing image processing operations (fig. 1). People often implement such algorithms using computers, which are flexible and are relatively cost efficient. Interest in digital image processing methods stems from two principal application areas[1]: (a) improvement of pictorial information for human interpretation, and (b) processing of scene data for autonomous machine perception.

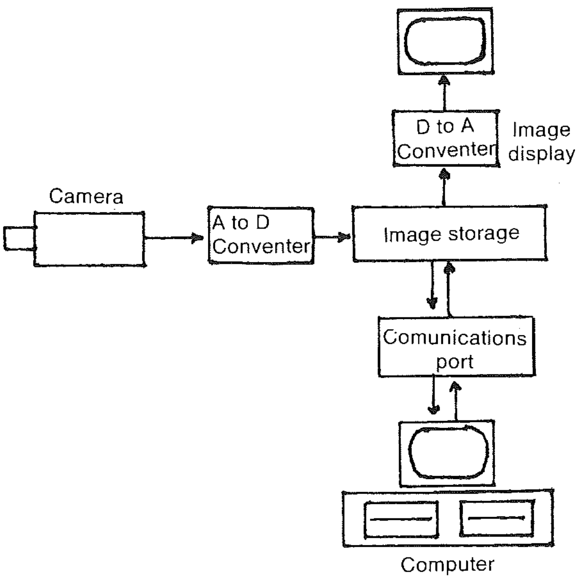
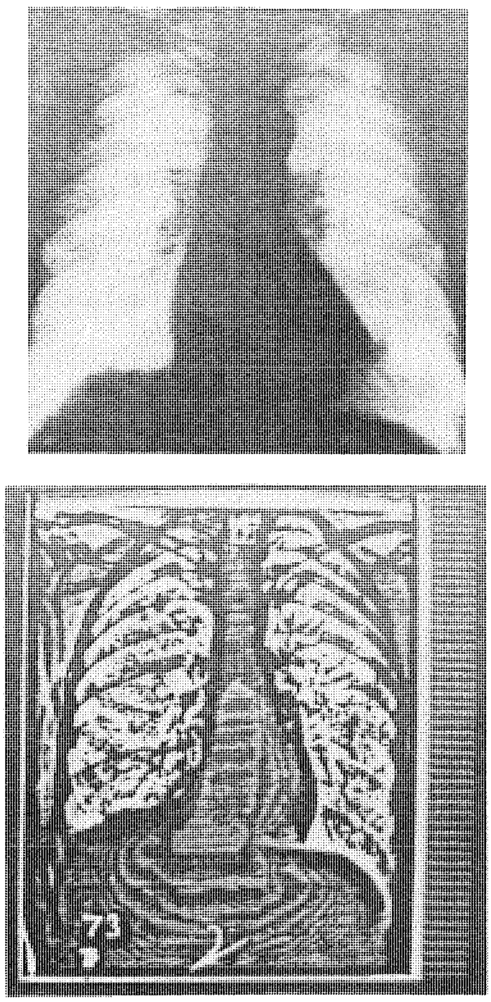


Fig 1: A frame grabber system

One of the first applications of image processing techniques was in improving digitized newspaper pictures sent by submarine cable between London and New York in the early 1920's. Some of the initial problems in improving the visual quality of these early digital pictures were related to the selection of printing procedures and the distribution of brightness levels. Although improvements on processing methods for transmitted digital pictures continued to be made over the next thirty-five years it took the combined advents of large-scale digital computers and the space program to bring into focus the potentials of image processing concepts. Work on using computers in improving images from a space probe began at the Jet Populsion Laboratory in 1964, when pictures of the moon transmitted by Ranger 7 were processed by a computer to correct various types of image distortion inherent in the on-board television camera. From 1964 the field of image processing has experienced vigorous growth. In addition to applications in the space program, digital image processing techniques are used today in a variety of problems which, although unrelated share a common need for methods capable of enhancing pictorial information for human interpretation and analysis. In medicine, for instance, physicians are assisted by computer procedures that enhance the contrast or code the intensity levels into color for easier interpretation of X-rays and other biomedical images (fig. 2). Similar techniques are used by geographers in studying pollution patterns from aerial and satellite pictures. Image enhancement and restoration procedures have been used to process degraded images depicting unrecoverable objects or experimental results too expensive to duplicate. For example, in archeology blurred pictures which were the only available records of rare findings lost or



(a)

(b)

Fig. 2 A practical example of contrast enhancement (a) original image, (b) transformed image, (From Ballard, D.H. and Brown, C.M. Computer Vision, Prentice-Hall, 1982).

damaged after being photographed, have been successfully restored by image processing methods. In physics, images of experiments of high-energy plasmas and electron microscopy are routinely enhanced by computer techniques. Applicatins of image processing concepts can be found in most areas of science, including astronomy, biology, nuclear medicine, pathology, law enforcement, defense and industrial applications.

The second major application area of digital image processing techniques is in problems dealing with machine perception. Interest is focused on procedures for extracting from an image information, in a form suitable for computer processing. Often, this information bears little resemblance to visual features used by humans in interpreting the content of an image. Examples of the type of information used in machine perception are statistical moments, Fourier transform coefficients and multidimensional distance moments. Typical problems in machine perception which routinely employ image processing techniques are automatic character recognition, industrial robots for product assemply and inspection, military recognizance, automatic processing of fingerprints, screening of X-rays and blood samples, and machine processing of aerial and satellite pictures for weather prediction and crop assessment.

Image recognition involves the use of special computer hardware to acquire and display images. The ability to process images using a computer is not only useful for pattern recognition, but it also covers computer graphics, image enhancement, image restoration, image analysis, image compression, and even special video effects for television.

This work and our final year project specifications, were initiated by our late supervisor Christophoros Solomou. We have made our utmost to complete the project specifications and implement his ideas, but this work would have been definitely better with him around.

In this paper we will briefly discuss some concepts and operations of image processing. We will describe the way images are represented and various operations that may be applied to enhance an image.

DIGITAL IMAGE REPRESENTATION

The term image refers to a two-dimensional light intensity function F(x,y), where X an Y denote the spatial coordinates of the value of F at any point[1]. F is proportional to the brightness of the image at that point. Any digital image, F(x,y), is been digitized both in spatial coordinates and in brightness. A digital image may be considered as a matrix where row and column indices identify a point in the image and the corresponding matrix element value identifies the intensity level at that point (fig. 3). The elements of such a digital array are called image elements, picture elements or pixels.

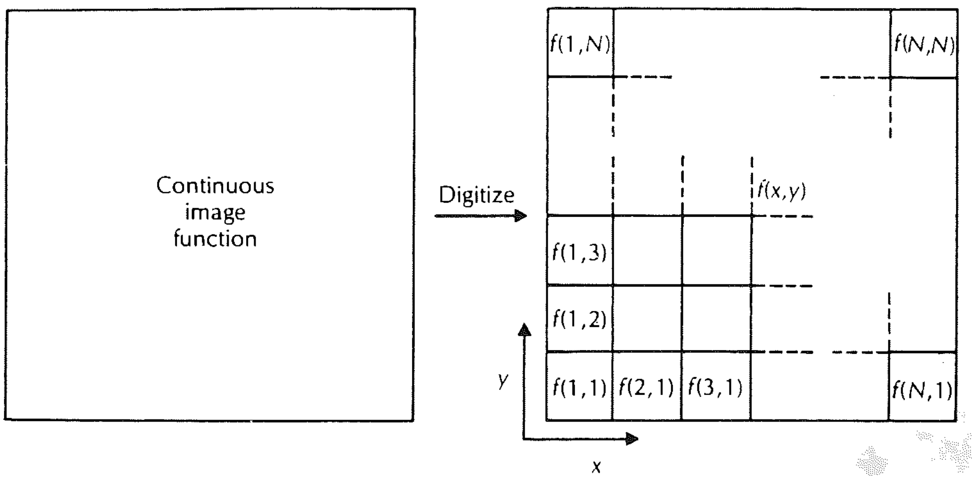


Figure 3 Definition of a pixel reference grid in image digitization

COLOUR IMAGES

Colour vision is a process that any colour can be defined as a triple of numbers (R,G,B) that give the amount of red, green and blue light that have to be mixed to produce that colour. This three-colour representation of a full colour image is possible due to of the way that human colour perception works, ie given any colour it is possible to find a mixture of red, green and blue light that reproduces it[3].

GREY LEVEL IMAGES

Another name for a monochrome image is a grey level image. In such an image each point is assigned a single number that indicates how bright or grey that point is. In principle, a point in the image can take any value betwen 0 and max (0 indentifies the darkest point and max identifies the brightest point in the image). Some typical values for max might be 15, 127, 255 depending on the application. All these values are powers of

2 because of the way the computer stores numbers (using binary arithmetic).

BINARY IMAGES

The extreme case of grey level images, gives rise to binary images. Binary images are the most economical for both storage and processing. These images use only black and white (0 and 1) as intensity values. For these reasons considerable attention has been paid to the manipulation and processing of binary images. To convert a grey level image to a binary, a threshold value has to be selected and then assign all grey level values less than it to 0 and all grey level values equal or greater than it to 1 (fig. 4). Of course, the results depend crucially on the value of the threshold. If the threshold is too high then all you see are a few bright peaks, whereas if the threshold is too low, then all you see are a few darker regions. Threshold selection is a very difficult task and there are methods for determining it. As expected, binary images hardly provide a good representation of the original grey level image.

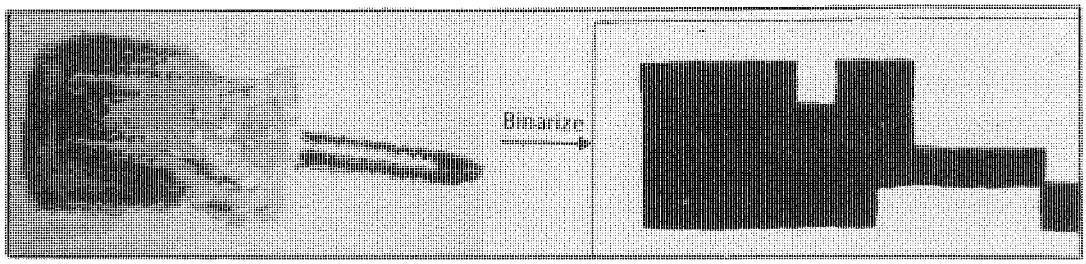


Figure 4 Approximation of a gray scale image through binarization

DIGITIZATION

The process of converting an image into an array of numbers is refered to as digitization. There are two components to be considered, spatial quantization and grey level or luminace quantization[3].

Spatial Quantization

Spatial quantization corresponds to sampling the brightness of the image at a number of points, usually a rectangular grid. Spatial quantization gives rise to an array of numbers A, which can be taken to be an approximation to the original image F(x,y). Each element of the array a_{ij} is refferred to as a pixel. This of course raises the question of how well A approximates F(x,y). In n^2 samples are taken at regular intervals within a bounding square then it is obvious that the approximation improves as n increases. Roughly speaking, as long as enough samples are taken, a spatially quantized image is as good as the original image. In practice, the type of sampling used is generally determined by the type of digitizing devices available.

Grey Level Quantization

Grey level quantization is necessary because of the need to consise storage and improve processing. In principle, F(x,y) and the elements of A can take any real value between 0 and MAX (the brightest point in the image), but in practice it is common to restrict the brightness values to a finite set of integers. This conserves storage because n bits are required to represent integers in the range 0 to 2^n-1. This means that, rather than the 16 or 32 bits needed to store a single real value, an image with integer grey levels in the range 0 to 7 needs only 3 bits per point. If 8 grey levels seem too few to represent an image, then 256 levels 8 bits per point, being need only an improvement over storing a 32 or 64 bit real value for each point. A second advantage of a restricted integer range is that integer arithmetic and integer operations are in general simpler, and hence faster than the equivalent fixed or floating point operations.

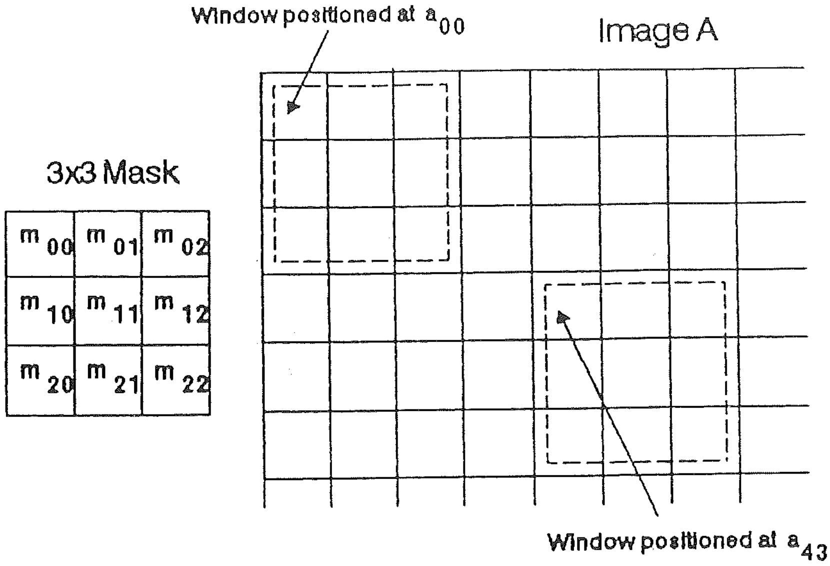
We still have to describe how values of F(x,y) are assigned to an integer in the range 0 to N. The most obvious method is to divide the range 0 to MAX into N+1 equal intervals - linear quantization - but it can be an advantage to use unequal intervals - non linear quantization - so that frequently occuring grey levels are covered by more integers. Using a variable or tapered quantization can improve the average accuracy of quantization.

OPERATIONS

A brief outline of some basic operations of image processing will be presented.

Area processes:

An area process uses neighbourhood information to modify pixel values or assert the existance of some property at the image points[4]. Area processes are typically used for spatial filtering and changing an image's appearance. Convolution (fig. 5) is a classic processing algorithm commonly used for spatial filtering in finding image features. The convolution operation replaces pixel's value with the sum of that pixel's value and it's neighbours, each



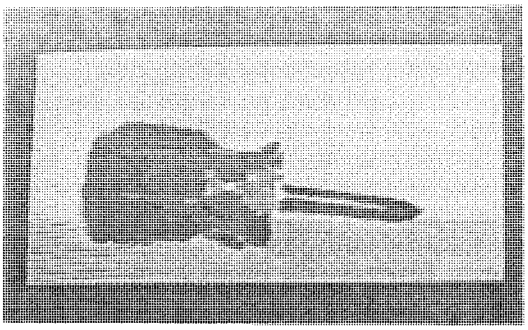
result at a_{43} = multiply and sum

$$= m_{00}a_{43} + m_{01}\,a_{44} + m_{02}a_{45} + m_{10}a_{53} + m_{11}a_{54} + m_{12}\,a_{55} + m_{20}a_{63} + m_{21}a_{64} + m_{22}a_{65}$$

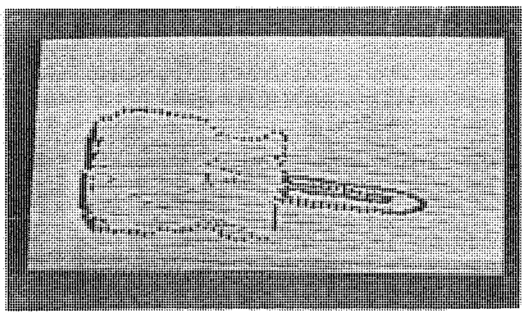
Fig. 5 Convolution with a 3x3 mask

weighted (multiplied) by a factor. The weighting factors form the convolution Kernel (or mask). The mathematical representation of the convolution operation is:

$$G(x,y) = K(m,n)*F(x+m, y+n)$$



(a)



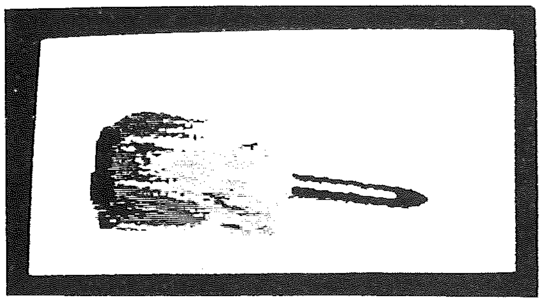
(b)

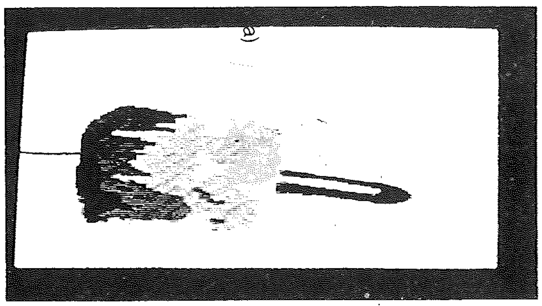
-1	-1	-1
-1	8	-1
-1	-1	-1

Fig. 6 Operating on an image to extract information about object outline and basic shape. (a) Image before processing. (b) Image after appropriate processing.

where: K(m,n) is the Kernel (matrix of size m * n), F(x,y) is the original image, and G(x,y) is the resulting image

There are many known masks for various operations. The most common are the edge detection mask (fig. 6) and the smoothing mask (fig. 7). Of course someone may create his own mask for the specific operation.





(b)

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Fig. 7 Example of the application of a smoothing algorithm (a) before, and (b) after smoothing

Point process:

A point process algorithm scans through the image area and uses the pixel value at each point to compute a new value for the point. You can use point processes to enhance or modify pixel values.

For example adding 40 to each pixel's brightness the image could improve its contrast. The transformation function is very simple it is denoted by:

$$F(x,y) = F(x,y) + 40$$

where: F(x,y) is the image

Geometric processes:

Geometric processes change the spatial arrangement of pixels. They are often used to correct distortions caused by the camera optics or viewpoint, or to enlarge an image area of interest. Typical geometric processes are rotation, stretching, translation of image position. Geometric algorithms can be expressed by a set of equations that map a pixel at location x, y to a new location x´, y´.

CONCLUSION

As reserchers try to give machines the ability to see, image processing becomes an increasingly important science. Also, due to the advancements in computer technology, both in hardware and software, new dedicated digital signal processors and new efficient algorithms are now available that allow fast processing of images. This led to the decrease of processing cost both in time and money. Most of the ideas described in theory can now be implement in practice using the existing technology.

Acknowledgement

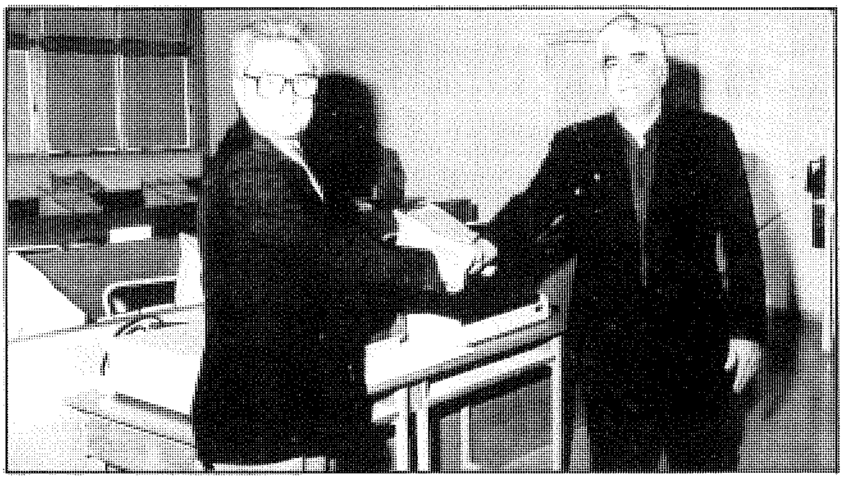
The authors would like to thank the Muscular Dystrophy Research Trust of Cyprus (MDRTC) for their support.

Special thanks should be given to Dr Christos Schizas and Mr Costas Pattichis for their valuable assistance during the completion of this article.

BIBLIOGRAPHY

1. *Rafael Gonzalez & Paul Wintz, "Digital Image Processing" Addison - Wesley Publishings, 1977*
2. *Michael C. Fairhurst, "Computer Vision for Robotic Systems. An Introduction" Prentice Hall International (UK), 1988*
3. *Mike James, "Pattern Recognition" Wiley - Interscience Publications, 1987*
4. *Benjamin M. Dawson, "Introduction to Image Processing Algorithms' BYTE Magazine, March 1987*

OBITUARY



The HTI Director, Dr Drakos, receiving the PC donated by Mr Solomou in memory of his son, Christophoros.

This academic year the Higher Technical Institute lamented the untimely loss of one of its lecturers, Mr Christoforos Solomou, who passed away on 10 February 1990 at the age of 28.

Christoforos had bravely fought against Leukemia for nearly two years. His death followed a bone marrow transplant operation.

Christoforos studied computer science at graduate and postgraduate level in the USA and joined the HTI staff in 1986.

Staff and students attended the funeral and the HTI Director, Dr Themos Drakos, delivered the funeral oration.

The HTI Staff Union paid tribute to his memory and arranged with the Management of the Institute to:

a) bear the cost of his funeral.

b) offer financial help to his family.

c) raise the flag half-mast for three days.

d) name the computer laboratory after his name.

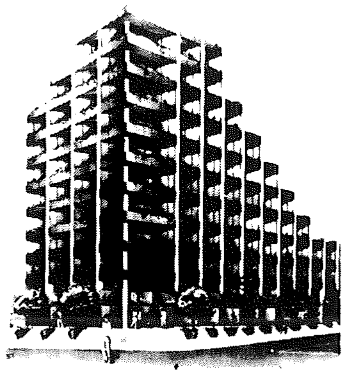
e) put up his photograph in the computer laboratory and staff common room.

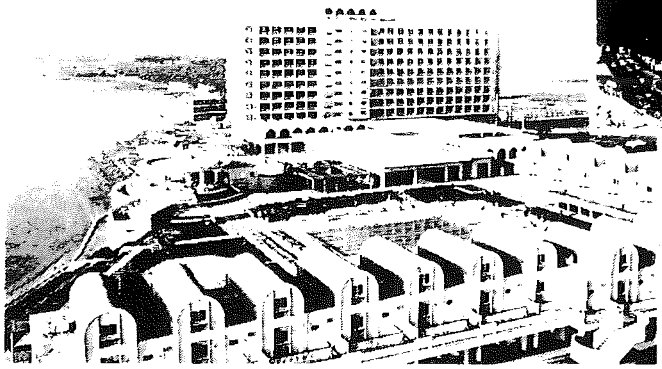
His family in appreciation donated their beloved son's personal computer and printer to HTI.

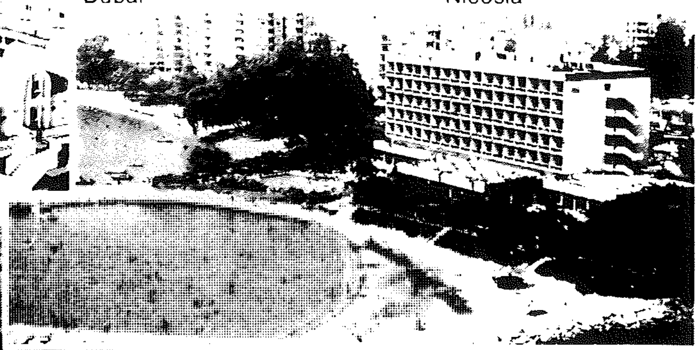
The Best in Civil Engineering and Building

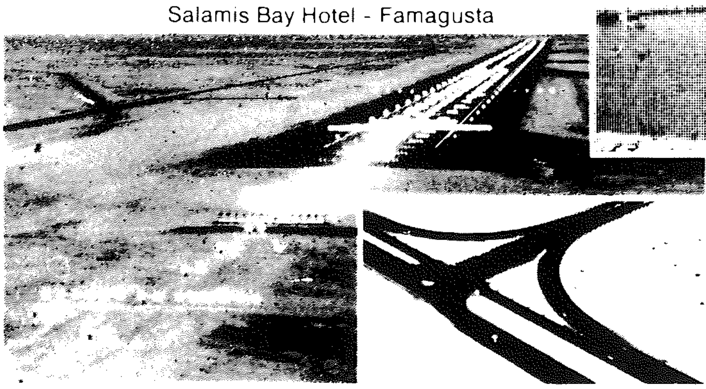
Από το 1950 κτίζουμε και δημιουργούμε τόσο στην Κύπρο όσο και στο εξωτερικό.
Μια δυναμική παρουσία, σ' όλα τα επίπεδα.
Διαθέτουμε και τα μέσα και την πειρα. Κερδίσαμε την εκτίμηση και την εμπιστοσυνη χαρη στη συνέπεια και την ποιότητα της δουλειας μας.
Με έργα... όχι μόνο λόγια.

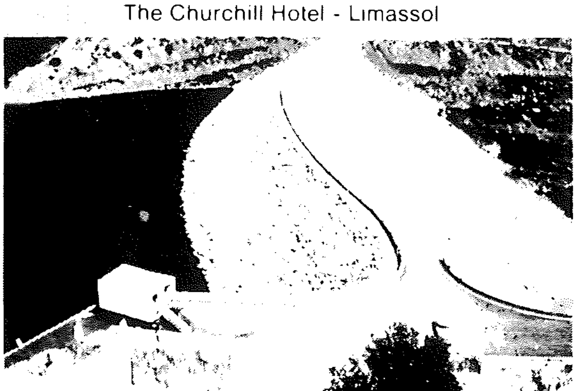

Deira Revolving Tower
Dubai


Medcon Tower
Nicosia


Salamis Bay Hotel - Famagusta


The Churchill Hotel - Limassol


Dubai Runway & Highway


Lefkara Dam


Eden Hotel Appartments - Limassol

MEDCON CONSTRUCTION LTD

24, Voulgaris St. P.O.Box 1054, Nicosia - Cyprus,
Tel 02-475111,2,3 Telex 2548 CY Telegrams: Builders
Telefax 02-452549

advantage

Neural networks as classifiers

This work has been sponsored by the Muscular Dystrophy Research Trust of Cyprus

Christou Demetris, Constantinou Renos,
Final Year Students Computer Studies, HTI

INTRODUCTION

In this case study we are going to examine a new type of classifiers which are based on Artificial Intelligence methods. A general introduction to Neural Networks will be given, followed by current software and hardware applications. A brief view of how neural nets are compared to conventional expert systems will be given. The theory of single layer perceptrons will be exposed, as well as their applications in the classification of simulated data. Multi-layer perceptrons will be presented and the back-propagation algorithm associated with their training will be discussed.

1. What are Neural Nets

Artificial Neural Network (ANN) models, or simply neural nets go by many names such as connectionist models, parallel distributed processing (PDP) models, and neuromorphic systems. Whatever the name, all these models attempt to achieve good performance via dense interconnection of simple computational elements. Their structure is based on our present understanding of the biological nervous systems. They are composed of elements that perform in a manner that is analogous to the most elementary functions of the biological neuron. These elements are then organized in a way that may (or may not) be related to the anatomy of the brain (reference 1).

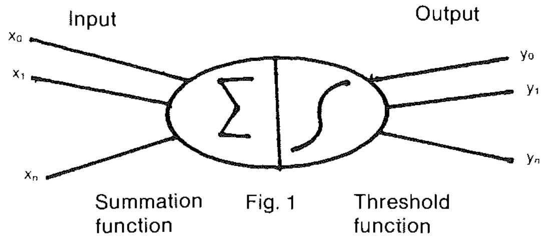


Fig. 1

This simulated neuron, or unit, has four components:

- input connections (synapses), through which the unit receive activations from other units
- a summation function that combines the various input activations into a single activation
- a threshold function that converts this summation of input activation into output activation (eg, perhaps zero output activation if the input activation falls below some threshold)
- output connections (axonal paths) by which unit's output activations excile as input activation at other units in the system.

Under the neural network approach, information processing occurs through interactions involving large number of simulated neurons (figure 1), operating in parallel, and producing an internal representation of an input vector (set of inputs x0, x1, x2, ..., xn). Each interconnected neuron can send/receive signals from its neighbouring neurons, in the form of numerical patterns. The numerical base of the neural network approach provides a ready means by which to represent continuous gradations in such things as the intensity of an input feature, the certainty of a classification, or the importance of a connection between two units. So, each simulated neuron acts as a feature detector (or classifier). It is through the combined effects of large numbers of such classifiers and input units feature detectors that intelligent behavior can emerge from a Neural Network (reference 7).

2. Applications using Artificial Neural Networks

Some of the applications in which neural network algorithms have been applied are listed below:

- Conversion of text to phonetic representations, which were then converted to speech by other means.
- Recognition of handwritten characters. Recognize the letters of the alphabet.
- Speech recognition. Recognize english phonetic words, and phrases.
- Medical diagnosis. Neural networks have been trained, using data from electromyography, to distinguish between several classes of neuromuscular diseases.
- Weather forecasting. An application which is under research, and it deals with forecasting the minimum temperature of the next day.
- A very interesting application using neural networks was done in Carnegie Mellon University: autonomous vehicle navigation. The goal was to drive the NAVLAB vehicle along a winding road.

3. Neural Networks in Practice

Neural networks have been mainly an area of university research for a long time. But in the last few years many companies became interested in the field and commercial products based on neural networks are now available.

Apart from a long list of books and articles, software and hardware have been developed.

Software

Neural Network software covers the whole spectrum of users. At the low-end there are tutorial, example and simulation systems such as The Brain Simulator, Brainmaker, Connections (modelling the travelling salesman problem) and Awareness (reference 10).

ANN applications are also available for areas such as text retrieval, signal recognition and vision recognition. The number of applications is yet small but it is growing steadily. At the high-end development systems, platforms and toolkits are available for serious work. Integrated neural network development systems include the N-NET, Cognitron, AXON, N1000, Neural Works, NeuroShell, HyperBrain and ANSim (reference 10).

Hardware

Dedicated chips, co-processors and accelerators have been configured or even developed for neural network applications such as ANZA series, Intelligent Pattern Recognition Chips (stores a 1000x64 matrix of weights and multiplies it with an input vector), Delta floating point processor, DENDROS and TRW Mark V (reference 10).

Neural Networks products cover the whole spectum of computer industry ranging from IBM AT and PS/2 machines, Sun workstations, RISC-based machines, the NeXT computer, the INMOS transputer, Apple Macintosh, VAX/VMS and Unix.

4. Neural Nets and Expert Systems

Two important contrasts between the neural-network approach and a more conventional rule-based approach found in AI expert-system work are the following:

- The knowledge of a neural network lies in its inter-unit connections and their weights. In contrast, much of the knowledge of an expert system lies in its rules (i.e., its condition/action or if/then Pairs).
- A neural network is driven by the activation that passes from units to other units. In contrast, an expert system is driven by symbols generated as a consequence of rule-firing.

5. Ability to learn in Neural Nets versus conventional computation

One of the disadvantages of computers is that they have no intelligence. Instead, they are always instructed of what to do, on a step-by-step basis through program statements. Every time they perform a task they need the program to instruct them. They might be doing the same task million of times, but they will not gain any kind of experience. However, the human being, doing the same thing many times will gain much experience. In the Artificial Intelligence world we call this learning.

Learning plays a central role in Artificial Intelligence, and many algorithms have been developed by AI researches, for this purpose.

Learning is achieved through training. A neural network is trained so that application of a set of inputs produces the desired (or at least consistent) set of outputs. Each such input (or output) set is referred to as a verctor. Training is accomplished by sequentially applying input vectors, while adjusting network weights according to a predetermined procedure. During supervised training, the network weights gradually converge to values such that each input vector produces the desired output vector. That change (adaptation) in the weights is what we call learning in ANN.

6. Single Layer Perceptron

Single layer perceptrons or simply perceptrons were introduced in 1943 by McCulloch and Pitts. The single layer perceptron is the simplest net that can exist. It is composed of a single node that performs a weighted sum of all inputs presented to it, substracts a threshold and passes the result through a non-linearity (sigmoid, hard limiter, threshold logic). The perceptron McCulloch-Pitts neuron is shown in figure 2.

If the net sum is greater than the threshold the output is high (one) otherwise it is low (zero).

There are many variations to the perceptron described above. For example the number of outputs could be more than one.

Perceptrons became a more important area of research in the 1960s boosted by the work of Rosenblatt and Widrow. However in 1969 Minsky and Papert made an in-depth study of perceptrons and came up with disappointing results, such as their failure to solve the well-known "exclusive-or" problem.

The findings of Minsky and Papert (reference 2) discouraged researchers and as a result interest in perceptrons dropped dramatically. Multi-layer perceptrons appeared later that were capable of solving the exclusive-or problem and other problems that single-layer perceptrons could not.

Single layer perceptrons are capable of classifying problems in which the sets of points corresponding to input values can be separated geometrically. For a 2-input case the simplest separator is a straight line.

For a 3-input the separator is a flat plane in 3D space. For higher, n-input cases the separator is a hyperplane. This cannot be mentally realized because of the many dimensions. However there are cases such as the exclusive-or problem that cannot be separated by a single straight line and thus cannot be represented by single-layer networks. These cases are linearly inseparable. As mentioned above linear separability is a criterion of whether a problem can be solved by a single-layer perceptron. Yet other factors such as the nature of the inputs play a decisive role.

The perceptron is trained by presenting a set of patterns to its input, one at a time and adjusting

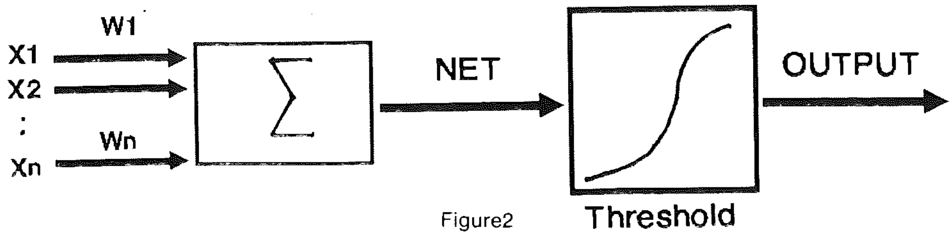


Figure2

the connection strenghts until the desired output matches the actual output calculated by the perceptron.

An example of single-layer perceptron learning is given in figure 3.

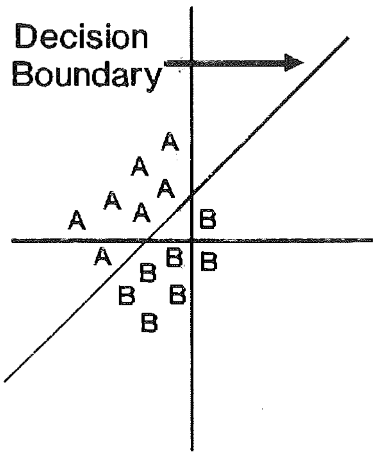


Figure 3

7. Applications of the Perceptron procedure

The first approach to use ANN in this study, was to use the perceptron algorithm to identify points between two classes (sets of points) in the X-Y plane. For illustration purpose consider figure 3. Points for the two different classes A and B were obtained randomly, between the range: -320 to +320 in the x-axis, and -170 to +170 in the y-axis. The points within each class had a definite distance between them, called the radius, and was kept within the range 5 to 50.

The inputs to the perceptron were the x and y coordinates of each point, and the CLASS to which each point was assigned (denoted 1 for CLASS A and 0 for CLASS B).

After the training set was generated, it was presented to the input of the perceptron. The learning peformance of the model was being measured by computing the TSS (Total Sum of Squares), which is the sum of squared difference between the desired and actual values at the output of the model. As TSS approaches zero it means that the correct classification is achieved by the perceptron and learning is completed.

Table 1 contains selected models and runs which were carried out. Figure 6 shows the decision boundaries formed after learning was completed for selected models.

After learning was achieved, the following evaluation procedures were applied:

(a) - The training data was used. All the points used to train the perceptron were used for evaluation. They were presented to the network and it responded with a calculated class. This class was compared to the actual class to which the points belonged, and an error rate was caclulated. This was very low ranging from 0 to 2% in most cases.

(b) - Evaluation data was used. It was randomly generated, in the same way as the training data was generated. The range of each class, was the same with that used for the training data. The procedure applied was the same as in (a). The error rate was calculated to be in the range 2% to 5%. All the points that were classified in class A were drawn on the screen in a different color from the points in class B.

8. Observations and Conclusions based on several runs

- The perceptron has been able to clearly identify points between two different classes of points in the x-y coordinate system.

There were cases where it could identify all possible points of each class. However in other cases not all possible points were classified. There was a small percentage classification error.

- After the perceptron was trained with a training set, and evaluation procedures were applied, a decision boundary was formed. Using the graphical evaluation procedure it was concluded that the actual decision boundary formed, was a straight line separating the X-Y plane into two regions. The equation of that line is given by the formula (1):

$$Y = \frac{-(W_O)\,(X_O)}{W_1} + \frac{\text{theta}}{W_1} \qquad (1)$$

- For each set of classes there might be an infinite number of lines which separate their correct boundaries. However, there are cases where there is no best line separating the two sets of data. In such a case not all points are classified correctly by the perceptron.

- Generally, the Total Sum of Squares (TSS) increases as the total number of training points increases. The last value of TSS (at the end of training) depends on the number of training points used, and it denotes the error.

- The gain term plays an important role in the convergence of the algorithm. When it was set to values over 0.1, the network could not converge, and there were oscillations of the value of TSS. Maintaining the value of gain term at low values, the rate of change of the weights and threshold values was smooth, so that the value of TSS had no oscillations.

- There were cases where learning was not achieved during training. In such cases the perceptron was possibly trapped in a local minimum. The efforts were concentrated on finding a way to drive the perceptron out of the local minimum. When the change in the TSS was not satisfactory, or there were high oscillations, it was found heuristically that by increasing the values of gain and threshold by a factor of ten for a number of epochs and then dropping them to their normal values, resulted in the escape from the local minimum and the subsequent convergence.

9. Multi-layer perceptron

Multi-layer perceptrons are feed-forward nets with one or more layers of nodes between the input and output nodes. These additional layers contain hidden units or nodes that are not directly connected to both the input and output nodes. A three layer perceptron with two layers of hidden units is shown in figure 4.

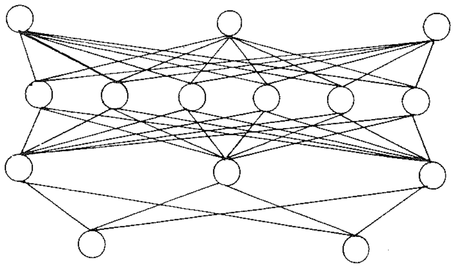


Figure 4

10. The back-propagation training algorithm

Back-propagation is the most popular continuous-valued learning algorithm today.

Before we present how the back-propagation algorithm works, we will make a reference to its predecessor: the Basic Delta Rule. For that reason consider the diagram in figure 5. An input

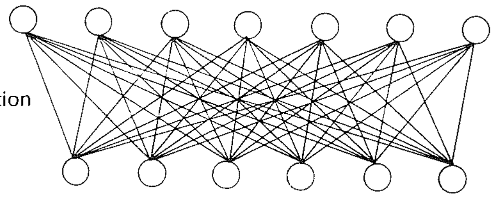


Figure 5 A network produced by the basic delta learning rule

pattern is represented by a vector of 0s and 1s that follow the ordering of input nodes in figure 5. An input pattern might be {1 1 1 0 0 0} and a target output pattern T might be {1 1 1 0 0 0 0}. Connections between all input nodes and all output nodes are randomly initialized with small numbers. Training using the delta rule then proceeds by cycling through the training pairs until a satisfactory level of performance is reached. On a given trial (epoch), the network first generates an output pattern Op in response to the input pattern Ip of a training pair. The discrepancy, or delta, between the actual and the desired behavior of the network is then determined by substracting vector Op from the target output pattern Tp of the training pattern. Under the delta rule, the post-trial change in the weight Wji of a connection between input Ui and output unit Oj is a function of the activation Ipi of the input unit and the delta (Tpj-Opj) associated with the output unit. Specifically,

Delta (Wji) = n(Tpj - Opj) Ipi (1)

where n represents a trial independent learning rate (known as the gain term). The equation that determines weight changes under the back-propagation rule is similar in form to that of equation (1). However, the back-propagation rule provides a more general means of computing the delta of a unit. On a given trial, the delta of an output unit is computed in much the same way as it is computed in the basic delta rule. Specifically,

delta(pj) = (Tpj - Opj)f' j (net(pj)) (2)

where f'j (net(pj)) is the derivative of a squashing function that operates on the sum of the inputs to a unit in order to determine the units output. A squashing function is a special kind of threshold function that is differentiable and nondecreasing.

The real power of the back-propagation rule comes from its assignment of deltas to hidden units that receive no direct feedback from training patterns in the outside world. These deltas, in turn, influence the modification of weights to connections leading into the hidden units. The delta for a hidden unit is computed as follows:

delta(pj) = f' (net (pj)) Sum(k) delta (pk) Wkj (3)

This is a recursive definition in which the unit's delta is determined by the derivative of its squashing function multiplied by the weighted sum of the deltas to which the unit sends activation via outgoing connections. A given delta term delta(pk) in the summation is, in fact, weighted by the strength of the connection pointing from the hidden unit Uj to the unit Uk that is the source of the delta.

As the back-propagation rule's name suggests, the basic idea behind this computation of deltas for internal units is to propagate back through the system errors that are based on observed discrepancies between the values of output units and a training pattern. The deltas are first computed for the output units, and these are then propagated backward to units that point to them, and so on, until the input level is reached. These deltas then drive the network's weight changes in much the same way as with the basic delta rule; the back-propagation rule, like its basic delta rule predecessor, is a gradient-descent heuristic (reference 7).

CONCLUSIONS

Artificial neural nets have demonstrated their ability in handling successfully applications where classical classifiers were facing limitations. However ANNs still have their own limitations, being heavy on computations and requiring a high number of training data (even though in this respect they behave better than classical classifiers). Hopefully new learning algorithms and neural net VLSI hardware will echance the use of ANNs in the future.

ACKNOWLEDGEMENTS

The authors would like to thank Dr Christos N. Schizas and Constantinos S. Pattichis for their valuable guidance, and also the Muscular Dystrophy Research Trust of Cyprus (MDRTC) for their support.

TABLE 1 SINGLE LAYER PERCEPTRON RESULTS

Fig.	Epochs	Train. Points	Eval. Points	Gain	TSS	Equation	Eval. of training set	Eval. of evaluation set	A(x)	A(y)	B(x)	B(y)	Radius
6a	6	100	100	0.05	0.0	-x ± 140	100%	100%	40	40	150	150	20
6b	8	100	100	0.0005	0.0	-1.5x+2048	100%	100%	40	40	150	150	20
6c	7	100	100	0.5	0.0	-5x+2.2	100%	100%	-20	-20	20	20	20
6d	9	200	300	0.05	0.0	-0.1x - 17	100%	97%	-15	50	0	-50	30

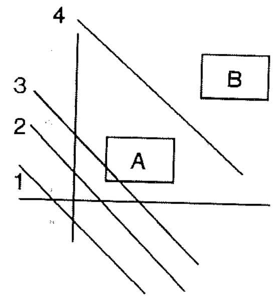


Figure 6a

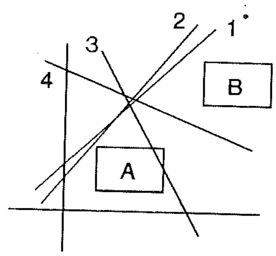


Figure 6b

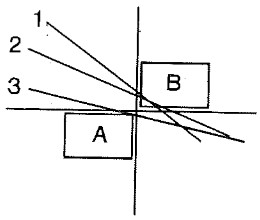


Figure 6c

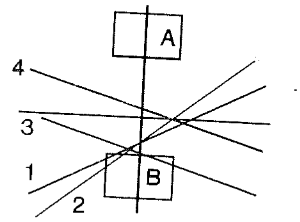


Figure 6d

REFERENCES

1. *Lippmann (1987)*
   Introduction to Computing using Neural Networks
   IEEE ASSP Magazine April 1987 (4-22)
2. *Minsky M. and Papert S. (1988)*
   Perceptrons
   MIT Press (Chapter 1)
3. *Wasserman D. (1989)*
   Neural Computing: Theory and Practice
   MIT Press
4. *NeuroComputing*
   Foundations of Research
   MIT Press
5. *Rumelhart D., McClelland J. (1988)*
   Parallel Distributed Processing Volume 1
   MIT Press
6. *Aleksander I., Burnett P. (1987)*
   Thinking Machines
   Knopf Press
7. *Jones W., Hoskins J. (1987)*
   Back-propagation: A generalized delta learning rule
   BYTE October 1987
8. *Brown R.J. (1987)*
   An Artificial Neural Networks Experiment
   Dr Dobbs Journal April 1987 (16-27)
9. *King T. (1989)*
   Using Neural Networks for Pattern Recognition
   Dr Dobbs Journal January 1989 (14-28)
10. *Tazelaar J.M. (1989)*
    In-Depth: Neural Networks
    BYTE August 1989
11. *Touzersky D., Pomerleau D. (1989)*
    What's hidden in the hidden layers
    BYTE August 1989 (227-233)
12. *Obermeier K., Barron J. (1989)*
    Time to get fired up
    BYTE August 1989 (217-224)
13. *Klimasauskas C. (1989)*
    Neural Nets and Noise Filtering
    Dr Dobbs Journal January 1989
14. *Carbonell J. (1989)*
    Paradigms for Machine Learning
    AI Magazine September 1989


UNIMASTER
Η ΣΠΟΥΔΑΣΤΙΚΗ ΕΓΓΥΗΣΗ
Τα έχετε όλα προβλέψει για τη μόρφωση του;
UNIMASTER της Universal Life,
το σχέδιο σπουδών
που εξασφαλίζει τα χρήματα
για τη πανεπιστημιακή μόρφωση
του παιδιού σας,
ό, τι και αν συμβεί.
Telia – Pavla

Predicting structural modifications of vibrating structures using raw experimental data

A. Stassis, BSc (Hons) Prod. Eng.
Ph.D, Lecturer HTI

1. INTRODUCTION

Today production techniques, are progressing rapidly, and machine tools are becoming more integrated with higher performance and working accuracy.

Flexible Manufacturing Systems require tools to exhibit increased metal removal rates. As a result chatter and excess vibration is created, having a negative effect on surface finish and accuracy. Tool wear, noise and damage of the machines is also a great problem.

Years ago researchers started experimenting with dynamic testing, mostly on aircraft. Accurate determination of natural frequencies and damping factors was assumed to be a great achievement. Major advances in electronics and digital analysis in recent years have resulted in many developments in structural dynamics and especially in modal testing. Not only dynamic characteristics can be found now but with proper programming, structural modifications can be predicted on a wide scale.

For modal testing and analysis a test structure has to actually exist because this method is experimental. Other methods are purely theoretical working only from the drawing board If we consider the pros and cons, modal testing is more favourable since modal parameters give a very good approximation to the *dynamic* behaviour of an *already existing structure,* no matter how complicated.

The flow chart in figure 1 shows the process used for improving already existing structures by predicting the influence of potential structural changes.

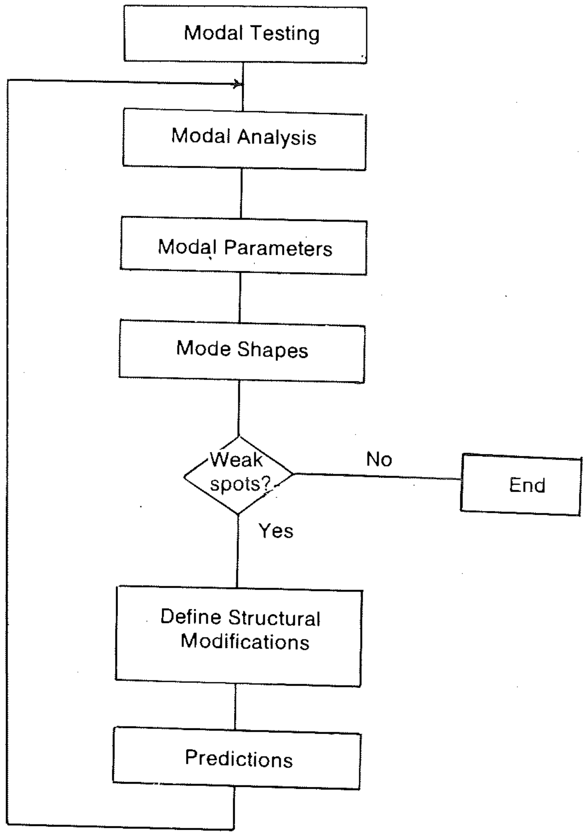


Fig. 1. Structural Optimisation Process

2. THE TESTING HARDWARE

Commercially available modal testing systems typically consist of an exciter, a force transducer, an accelerometer, filters, preamplifiers, a dual channel FFT analyser, a modal analysis processor, a graphics terminal, storage devices and plotters/printers.

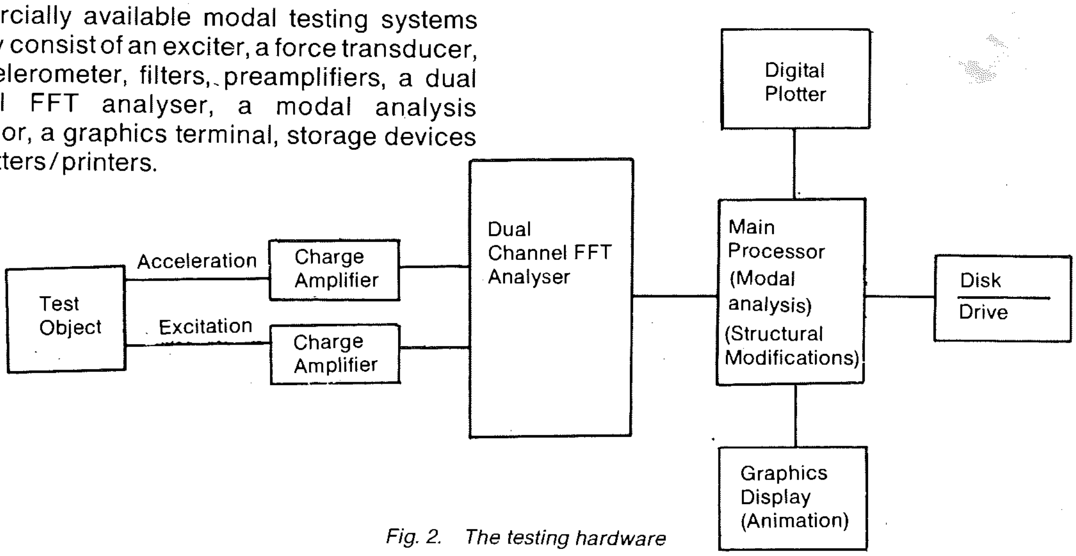


Fig. 2. The testing hardware

The response and excitation measurements can be directly transmitted to an FFT dual channel analyser via the preamplifiers and the transfer functions are then computed. These are stored on a floppy disk or hard disk ready for modal analysis. Structural dynamic analysers available today with dual FFT analyser, main processor, plotter, graphics display and storage facilities come as a compact unit.

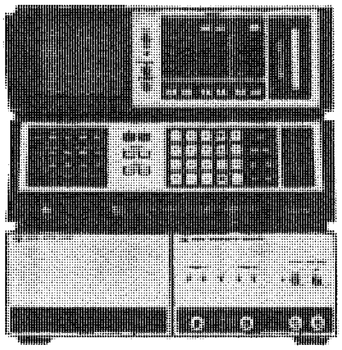


Fig. 3 A compact dynamic analyser

3. MODAL ANALYSIS

In Modal Analysis the measured data is processed to extract the modal parameters of the structure under test. These parameters generally are the modal frequencies of the structure ω_o the modal damping η, and the mode shape vectors $\{\psi\}$. These are the relative deflections of the shapes which the structure takes at each natural frequency.

Display or animation of these mode shapes at each natural frequency can be shown in 3D on the graphics monitor or plotter. It should be emphasised at this stage that this is the dynamic behaviour of the actual real structure under test.

Before testing, a certain number of points of interest are defined on the structure under test, and on each of these points the translations in three directions are measured. Then the number of degrees of freedom n is defined as three times the number of points. The more points you consider the better.

Behaviour of structures can be described with the help of transfer functions in the form of Receptances. With n degrees of freedom an nxn transfer matrix [H] is generated containing nxn hjk Receptance elements, where j demotes the response coordinate and k the application of the excitation force coordinate. Now if a system is excited by a series of {f} generalised forces then the response will be a set of {x} generalised displacements. It can be shown that

$$\frac{\{x\}}{\{f\}} = \sum_{r=1}^{n} \frac{\{\Psi r\}\{\Psi r\}^T}{m_r \omega_{or}^2 \ (1 - (\omega/\omega_o)^2 + i\eta_r)}$$

where

$\{\Psi r\}$ is the modal vector for mode r

m_r is the modal mass for mode r

$\omega_o r$ is the natural frequency of mode r

η_r is the damping factor for mode r

n is the number of modes or degrees of freedom

From the above equation, elements can be extracted. For example, the response at point j due to a single harmonic force applied at point k

$$\text{is } H_{jk} = \frac{x_j}{f_k} = \sum_{r=1}^{n} \frac{\{\Psi_{rj}\ \Psi_{rk}\}}{m_r \omega_{or}^2 \ (1 - (\omega/\omega_{or})^2 + i\eta_r)}$$

the above equation can be written in the form:

$$H_{jk} = \sum_{r=1}^{n} \frac{A_{rjk} + iB_{rjk}}{1 - (\omega/\omega_{or})^2 + i\eta_r'}$$

Now if the basic term:-

$$H_r = \frac{1}{1 - (\omega/\omega_{or})^2 + i\eta_r} \quad \text{is taken}$$

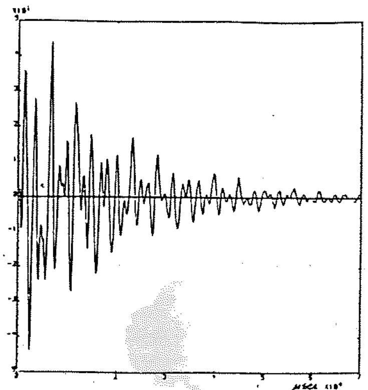
it can be shown that:-

$$[\text{Real}\ (H_r)]^2 + [\text{Imag}\ (H_r) + {}^1/_2\eta_r]^2 = [{}^1/_2\ \eta_r]^2$$

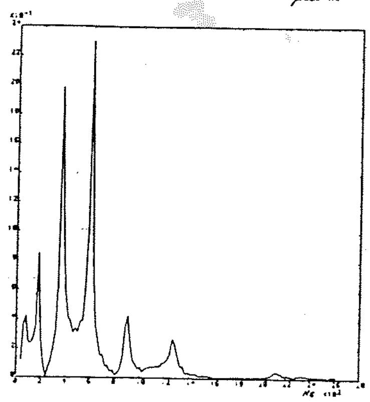
which is the equation of a circle with radius $1/2\ \eta_r$ and centre $(0, -{}^1/_2\eta_r)$. Plotting therefore the Transfer Functions or Receptances in Polar form enables the researcher using proper curve fitting techniques to extract the modal parameters ie $\omega_{or}, \eta_r, \{\Psi_r\}$ where r takes values from 1 ... m and m is the number of modes identified.

The diagram in Figure 4 shows the modal analysis procedure.

a) Sampling Data



b) Measurement of the frequency response functions



c) Curve fitting

d) Modal parameters

e) Visualization of mode shapes

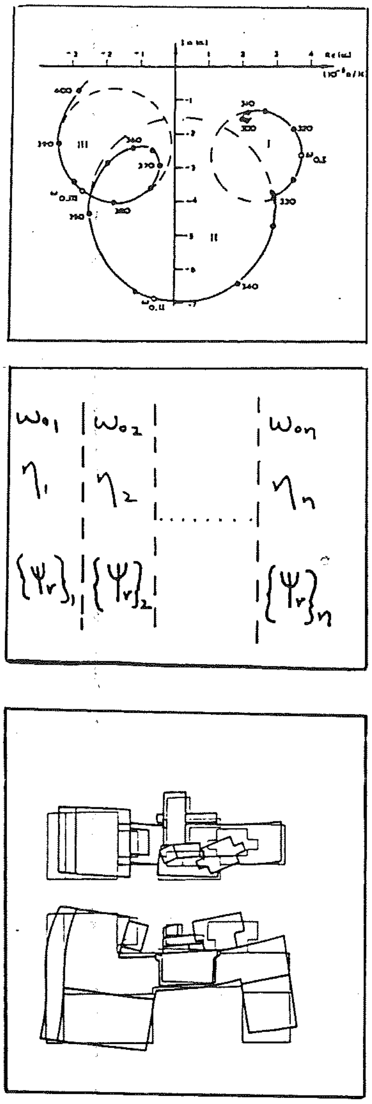


Fig. 4 Modal Analysis Procedure

4. Structural Modifications using the Receptances of Real Structures

It can be shown that Receptances of Composite systems can be calculated in terms of "adding" the Receptances of its subsystems (1)

Systems with linear equations of motion can use the principle of superpostion. Therefore if harmonic excitations are applied at two or more points on a system then the response at any coordinate is the sum of the responses which would be obtained if the forces were applied separately.

If the responses xa_j at these different coordinates on a structure A due to different excitations $F_k e^{i\omega t}$ are given by a series of equations:

$$xa_1 = \alpha_{11}F_1e^{i\omega t} + \alpha_{12}F_2e^{i\omega t} + \dots \alpha_{1n}F_ne^{i\omega t}$$
$$xa_2 = \alpha_{21}F_1e^{i\omega t} + \alpha_{22}F_2e^{i\omega t} + \dots \alpha_{2n}F_ne^{i\omega t}$$

$$xa_n = \alpha_{n1}F_1e^{i\omega t} + \alpha_{n2}F_2e^{i\omega t} + \dots \alpha_{nn}F_ne^{i\omega t}$$

Where n is the number of coordinates and α_{jk} is the Receptance of the system A due to an excitation force at point k and response taken at point j.

Similarly the response of a substructure B can be given by a series of equations:-

$$xb_1 = \beta_{11}F_1e^{i\omega t} + \beta_{12}F_2e^{i\omega t} + \dots \beta_{1n}F_ne^{i\omega t}$$
$$xb_2 = \beta_{21}F_1e^{i\omega t} + \beta_{22}F_2e^{i\omega t} + \dots \beta_{2n}F_ne^{i\omega t}$$

$$xb_n = \beta_{n1}F_1e^{i\omega t} + \beta_{n2}F_2e^{i\omega t} + \dots \beta_{nn}F_ne^{i\omega t}$$

Combining the above equations with equilibrium and compatibility equations at the points of contact (between the structure and substructure) complex algorithms can be developed (1) to enable structural modifications like the ones shown in the Library in Figure 5.

5. PROBLEMS ARISING IN MODAL TESTING

Since the input signals from the transducers are used directly either in identifying the characteristics, or for predicting structural modifications on any machine tool or structure, a great importance has to be given to the sampling of these signals. Errors like aliasing, leakage, windowing, transducer errors and calibration errors firstly have to be eliminated.

Predicting structural modifications requires numerous calculations. Small errors in the sampled data can accumulate rapidly. The more the modifications on the structure the more the errors, since the previous predictions are used as a basis for building up the new structure.

Many researchers try to create theoretical models using the modal parameters extracted out of modal analysis from the already existing experimental results(3). If the extraction of these parameters used for creating these models is not done with the highest degree of accuracy then not only the noise in the sampled signals is included in the model but also the initial errors occuring from the incorrect modelling are accumulated worsening the situation. This brings us back to the use of the raw experimental data as a better method because the errors due to modelling are excluded.

Another problem in addition to making accurate measurements is to physically connect the structures so that the Joints themselves do not affect the dynamic characteristics of the new structure. Research has shown that the accuracy of the predictions will be very poor if the Joints themselves are not taken into consideration(1).

Joining two structures by welding will show a big difference in the dynamic characteristics of the new structure than if, for example, the same joints had been bolted or glued. A lot of research is currently being done on compensating for the effect of the many types of joints. One of the biggest advantages of using raw experimental data to describe a structure is that no matter how complicated the structure is, and how many joints exist in the structure, the characteristics

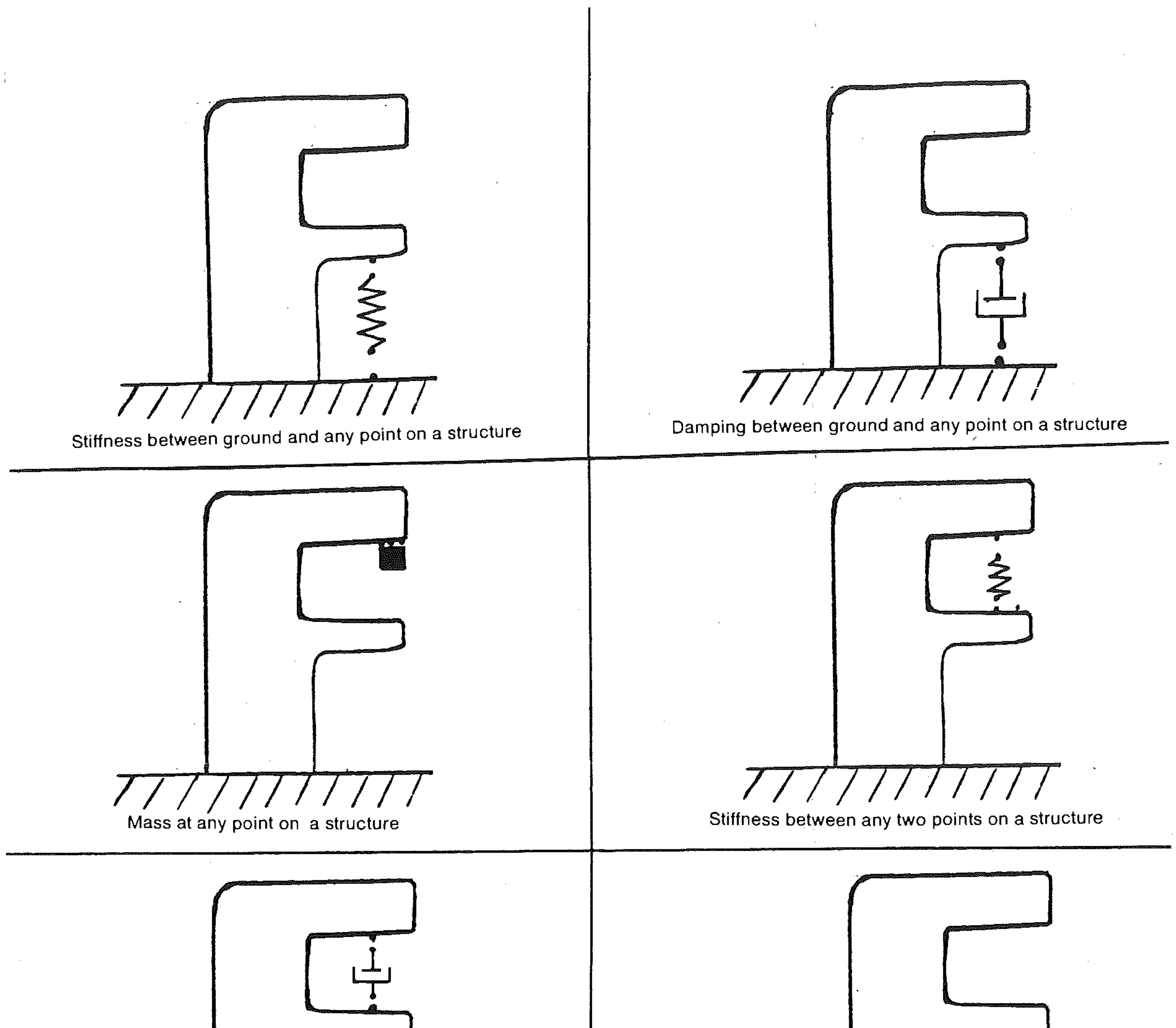


Fig. 5 Basic Structural Modifications

and effects of these joints are included in the responses taken from this structure.

We know for sure that inaccuracies exist in the dynamic description of existing structures using completely theoretical methods, such as Finite Element. Methods like these are useful when a completely imaginary structure is described. Data extracted out of imaginary substructures can be used in conjunction with completely experimental data to predict modifications on an already existing structure when a completely imaginary part is added (1).

6. CONCLUSION

Using completely raw experimental data in the form of Receptances complicated existing structures can be systematically improved by predicting the effect of their structural changes. This method makes it easier to obtain more realistic results because effects of joints, damping and any other factors influencing the structure are inherently included in the data describing the structure. Although care is needed while sampling advances in digital electronics today make it possible to ensure that errors due to sampling are kept to a bare minimum. This makes the use of Raw experimental data in the form of Receptances a very attractive method for predicting modification and optimizing machine tool performance.

REFERENCES

1. *Stassis A.*
   The systematic improvement of vibrating structures using computer based tests and predictions PhD Thesis 1986
2. *Ewins D.J.*
   Modal testing theory and Practice
   Research Studies Press
3. *Whittaker A.R.*
   Optimization of the dynamic characteristics of machine tools using experimentally based Mathematical Models PhD Thesis 1980
4. *Stassis A.*
   Structural modifications using raw frequency response functions.
   Proceedings of the 11th International Seminar on Modal Analysis, Leuven Belgium 1986.

Life is composed of doing the things that need doing whether one feels in the mood to do them or not.

Sir BASIL HENRIQUES

" Scientific research has shown that an insufficient degree of everyday fun can actually destroy your emotional balance".

ROBERT MINES

The work done by the heart per day is of the order of 25,000 kilogram-meters! Contemplate this fantastic matter.

PC's as controlling elements

Eleftheriou Polyvios, Ph. D
Lecturer HTI

1. INTRODUCTION

Programmable Logic Controllers (PLC's) are usually used to control a series of devices and/or manufacturing machines. PLC's though are expensive and not as flexible. The rapid expansion of the computer industry offers an alternative to the PLC's. Personal Computers can often be used in places where sophisticated control is required. Especially as the processing speed of the PC's is pushed to higher levels this aternative becomes more appealing.

2. PC's IN THE INDUSTRY

Even though is very hard to use PCs in all the industries due to several reasons, like the harsh environments, in most cases the PC's are very much a cheap alternative. PCs are usually used as.

(a) a design tool,

(b) a data acquisition tool, and

(c) a controlling element.

As a design tool personal computers are used lately not only for drafting, but also for solid modeling. The appearance of solid modeling software for the PC makes it a very powerful alternative to even the microcomputer workstation.

Data acquisition can be performed using a PC and special hardware in two ways. Either by an expansion chassis or plug-in boards. If the number of data channels to be read is less than a few hundred then the plug-in board is a wise choice. Those special boards offer a variety of programming capabilities. Digitizing speeds up to 10 MHz can be found today in the computer market. The expansion chassis offers a solution to "cheap" data acquistion for a large number of data channels and future expansion. This method is rather more expensive and offers more capabilities (such as more power output etc.).

As a controlling element the PC can be used today either as an on/off or a digital controlling element. In the on/off case the computer communicates with relays via its I/O ports and the programming is rather easy. The digital control is more complicated, but it may be used for more sophisticated control circuits.

3. APPLICATION OF THE DATA ACQUISITION/CONTROLLING ELEMENTS OF THE PC.

3.1. *The problem*

The problem to be analysed here has to do with the measurement of the velocity profiles downstream a large number of duct fittings, analyse, and present the data, and find the different flow variables of the fittings.

A special computer controlled system was constructed in order to perform this task. This shown in Fig. 1.

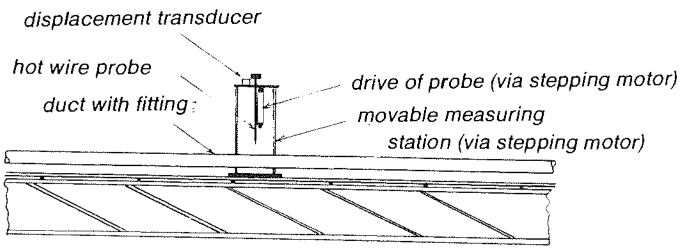


Fig. 1 The measuring system

3.2 *The system*

The system had two mutually perpendicular hot wire probes which could be moved across the duct diameter via stepping motors. The whole assembly could also be moved along the duct so as to repeat the data taking at different positions along the duct.

A PC was selected to both control the system, and to gather the data (both displacement and velocity). A general purpose data acquisition plug-in board was purchased and programs were prepared to handle this large amount of data required.

The computer communication with the stepping motors was achieved via a "centroid controller" (a device which can be interfaced with the serial port of the PC and accept information from any high level language). The information flow is shown in fig. 2.

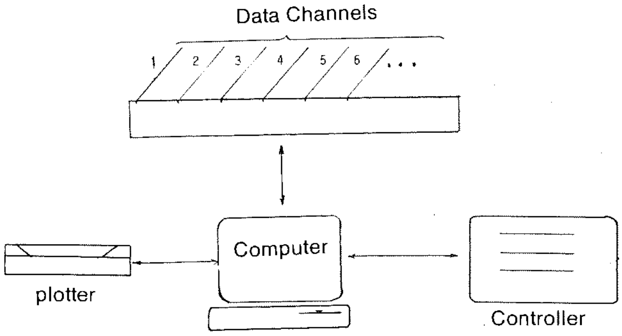


Fig. 2. The computer System

3.3. *The controlling program*

The PCs was programmed to do the following sequence of events:

(a) *Position the probes at the starting point,*

(b) *Zero all the variables and open the required data files,*

(c) *allow the hot wire probes to move across the duct and multiplex the displacement/*

velocity channels at the desired rate, saving the data in memory,

(d) retract the probes and move along the duct to the next measuring location,

(e) repeat the above on request, and

(f) stop

3.4 ***Data processing***

Since the data were put in files another program could process them all at once, perform the graphical representations, and put the output in a desired form.

Some of the data collected is shown here (Fig. 3).

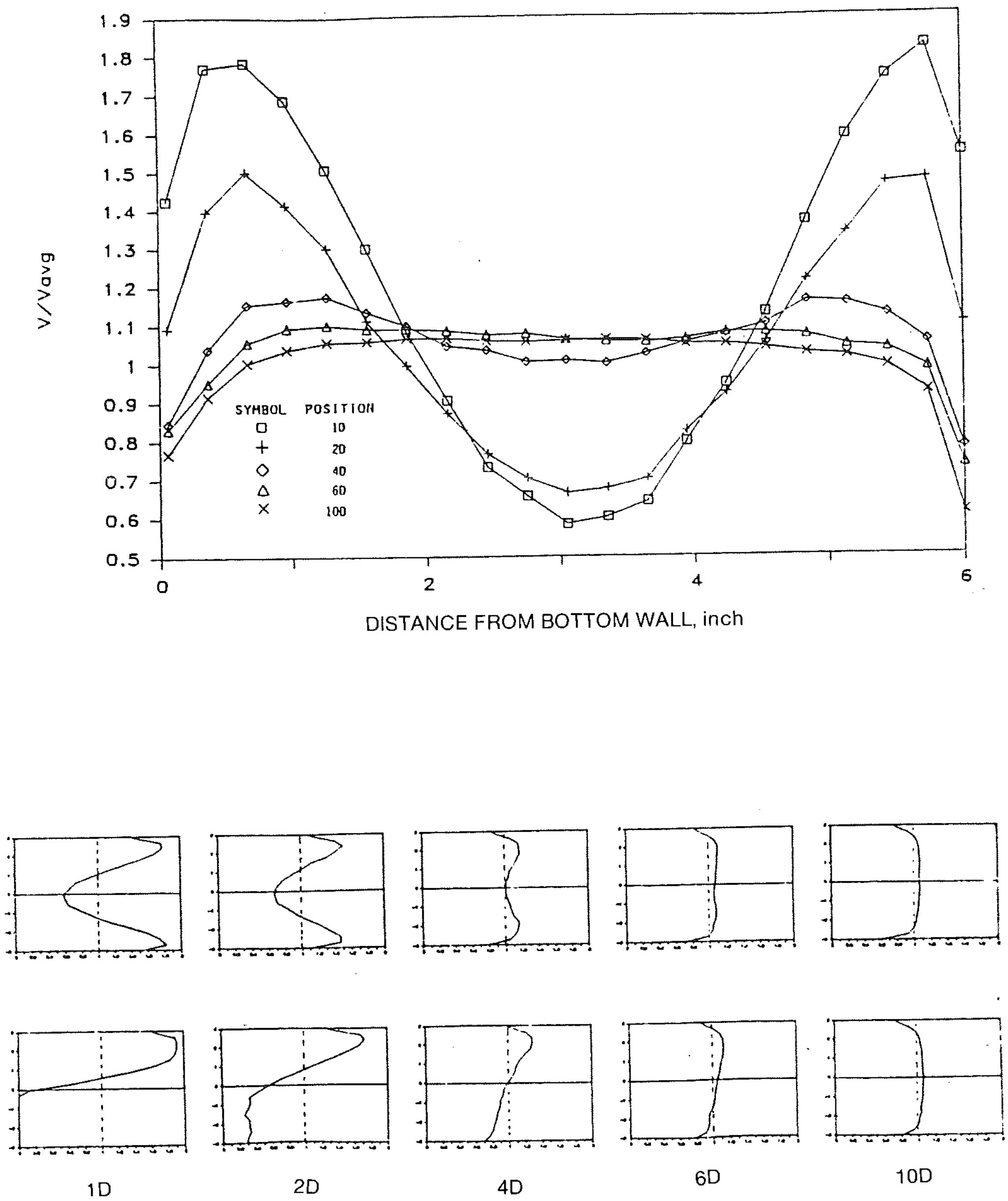


Fig. 3 Velocity development in pipes (fittings)

How to choose a computer

Maria Tsinda BSc, MSc, MBCS
Lecturer HTI

INTRODUCTION

To select a computer system and to ensure that work is available for the computer on istallation requires active management participation. This participation is the creation and implementation of an acquisition and installation. A plan created by management is necessary because:

1. **The acquisition of a computer is a major project involving a large financial outlay;**
2. **The acquisition of a computer requires management policy decisions;**
3. **The acquisition of a computer requires special building and environment;**
4. **The acquisition of a computer requires the creation of Data Processing Department or division;**
5. **The planning of work for the computer usually involves many areas of departments within the organization.**
6. **Nowadays the installation of a computer system takes a short period and failure to meet target dates in software applications unexpected additional expenses may be incurred because the old system has to be ratained; and**
7. **Failure to select the appropriate system may result in losing a lot money.**

AUTOMATION

The whole of automation is a big, deep pond. There are many mean fish in that pond. Those who get in before they learn how to swim will drown. Those who do know how to swim but do not keep a sharp look out for sharks will be eaten.

Be warned!!

The acquisition of a computer system is a big decision because it involves a large financial out lay. Once acquired the user is locked into it. The decision for the acquisition of a computer system must therefore be one that the user is prepared to live with for at least several years in order to justify the investment. But which of the many computer systems which are today in the market is the proper one? This leads to a more difficult decision because no one can predict what will happen tomorrow in this very fluid, complex combination of technological pressures and market demands.

Will software development which nowadays is expensive be more expensive tomorrow? What happens if software development does not proceed according to the plan for the organization's system? Will more people be hired?

Computer systems can be defined as a working symbiosis of machines and people. If negative attitudes are developed by the people in the organization how are these sociological problems faced? What will be the financial loss if the proper system is not selected and who will be blamed? Unfortunately it is not possible to determine how all these problems should be solved or balanced. These problems or factors are only brought up and every organization must take its own decisions.

Acquisition of a Computer System

After the need for a computer system has been identified (by a feasibility study carried out by a qualified person) the organization should prepare a request for tender (RFT) and send it to the various vendors who in turn will make their proposals. Part of this tender document should be a writtern functional specification.

The development of such a specification is a time consuming project requiring considerable expertise in computing. If an organization does not have a qualified person to draw up this specification it is advisable to acquire such services by a paid consultant.

Trying to save money now without benefit of a knowledgeable expert will result in wasting money later. A functional specification that is deliberately set up to match a certain computer manufacturer's products line is not worthy of the name. The functional specification has important implications for the future of those users and organizations that may ultimately acquire the system. Therefore this should be considered as high level document reflecting the opinion of those in authority and carries their sanction.

Organizations which select computer systems with the information provided only by the computer manufacturer's sales representatives have no one to blame but themselves if and when failure comes. Some of the basic factors to be included in the functional specifications are:

1. Present Applications and proposed ones.

All present and proposed applications - if any - should be described in detail in this part of the specification. First specify the applications that the system is to serve. Then describe the file characteristics, the types of inputs and outputs, volumes and frequencies. If the organization anticipates that in future it will need additional memory more secondary storage, more on-line terminals, more powerful software etc. this should be specified. The disclosure of the organization's future plans for automation will facilitate vendors to make a proposal for a good system and not the cheapest one.

Try in this part of the specification to give the vendor the general range of capabilities and level of performance that the organization is expecting from the system.

2. Hardware and Software tools

Under this part of the specification the organization specifies its needs in hardware and software. This part is very technical but as it was stated the functional specification should be prepared by a qualified person or consultant who is expert in computing.

3. Documentation

In this part of the specification the kinds of literature that the organization needs are included, such as user manuals, system manuals, operating systems, programming language, software utilities manual and any other documentation which is essential.

4. Installation

The projected dates for placing an order and for installation of the computer system should be stated under this part of the specification. Kind of penalties if targets are not met should also be stated. Apart from this functional specification the vendor should be asked to give information of similar installations in the area and to provide arrangements for demonstration and describe how the organization can access the proposal configuration to evaluate its performance.

PROPOSALS EVALUATION

Currently many organizations employ extremely subjective methods to evaluate proposals. Meaningful criteria should be established for evaluating each proposal from the various vendors. Such criteria should include:

a. Performance
b. Presence of special application software
c. Ease of conversion
d. Response of other users having the same system
e. Expandability
f. Upwards software compatibility
g. Restrictions of compatibility with other systems.

The team evaluating the proposals should assign a weight to eachcriterion.It may be possible to eliminate certain vendors because of one basis failure such as:

a. The lack of key applications packages that are critical for the organization
b. Failure of a vendor to provide demonstration
c. No other system in the area to provide back up in case of emergencies
d. No maintenance services are provided.

If it is not possible to eliminate vendors one by one then a format evaluation procedure is necessary.

One approcah is to assign the interval scores to each vendor in each criterion and multiply this score by the weights of the criteria. These weighted scores should be added up to produce a final weighted total. If the results are too close then carry out a sensitivity analysis or prepare a brief senario.

Nowadays the emphasis on evaluation has shifted from the capabilities of the hardware to the ease of use and power of software because software nowadays is very expensive.

CONCLUSION

Before deciding to select a computer system hire a computer expert to carry out a feasibility study in order to identify the type of system which is best for your organization. Let this expert draw up a functional specification as part of the tender document. Investigate what each vendor's past behaviour has been regarding hardware and software maintenance. Consider serious systems which restrict the range of hardware and software that will be compatible with your data processing activities in the future. Once locked into the product line of a given computer manufacturer you are generally stuck with it. Be warned!!

Consider seriously the financial standing of the supplier. Many who purchased computer systems found that the supplier went out of the computer business leaving them without any kind of support.

Do not gamble to be the first customer of a new computer manufacturer even though he may make the best financial offer.

Choose a vendor that values his reputation and that values you as a customer...

1. *2nd Printing is free for the pages which have mistakes from our side.*

Management of medical engineering, perspectives of developing countries *

Dr. Andreas Mallouppas, Senior Lecturer
Head Regional Training Centre

1. The Problem

At present in developing countries there is an inability to provide **efficient, effective, safe** and **affordable** health care at **all** levels[1]. This is mainly due to the lack of technical know-how, tradition and infrastructure of national Health Care Technical Services (HCTS). The problem is further exacerbated by the limited availability of foreign currency and by the influx of high technology at all levels and types of equipment. The general economic and logistic support[2] that the health sector needs from other sectors of the national system, such as roads and telecommunications, is largely wanting, and inefficient operation of customs procedures and of inter-sector coordination, poor collaboration and weak management worsen an already adverse situation.

2. Major Consequences of Present Situation

There is therefore an appreciable wastage of limited national resources, as the following table shows[3].

Cause	Estimated Waste
- Purchase of sophisticated equipment, which is under-used or never used, owing to lack of operating and maintenance staff and medical expertise to support and use it	20% - 40% of equipment
- Limitation of the useful life-time of equipment due to inexperience of operators and lack of servicing	Reduced by 30% - 80%
- Additional purchase of accessories, extras, specialized spare parts and testing equipment and building modifications, initially unforeseen owing to lack of expertise in choosing appropriate systems in the first place	10% - 30% of value of equipment
- Lack of standardization resulting in increased costs of spare parts and extra work-load on the limited competent staff	30% - 50% extra spare parts costs
- Excessive down-time of equipment, i.e. time they remain inoperative, owing to lack of spare parts, inexperience in repair and lack of preventive maintenance	25%-50% of equipment
- Lack of liquidity in foreign exhange reserves, which forces countries to accept unfavourable purchasing contracts	10%-30% extra purchasing costs of equipment and spares

3. Identification of the Major Obstacles Facing the Health Sector

It is obvious that the obstacles that impede the health sector can be overcome only if other national sectors also improve, such as roads and ligistic support, telecommunications, and management and coordination within the government service.

The four major obstacles in developing countries are:[4]

a) Lack of organizational policy;
b) Ineffective Health Care Technical Service (HCTS);
c) Inadequate Manpower Development and Training;
d) Insufficient Information Support

3.1 Lack of Awareness and Policy Commitment

At present inadequate awareness of the magnitude and interdependency of the problem and the limited expertise of policymakers, planners and managers prevent the necessary policy formulation, planning development, securing of funding and identification of all aspects that must be considered in defining effective policies on and in the management of health care equipment.

Figure 1 shows the **Cycle** of events that should be considered when formulating the necessary planning interventions in order to meet national **Health Needs** based on medical necessity. At the stage of policy formulation decision-making should involve **all the parties** concerned with equipment management in a collective, team approach, not an individual or one-sevice decision.

Once the health needs have been identified, the necessary interventions must be taken into account. These include types of equipment, physical facilities, funding requirements, logistic

* Paper presented at the 23rd Conference of the Council for International Organisations of Medical Sciences, WHO/Geneva, 2-3 November 1989.

support, and local market support, particularly in spare parts and technical information. Equipment procurement involves the determination and quantification of general technical specifications, spare-parts needs, personnel training (both user and service staff), and service workshop facilities in calibration and testing of equipment. This must be done and the facilities made available at or before the installation of the equipment.

3.2 Ineffective Health Care Technical Service (HCTS)

The inadequacies in infrastructure (human and physical facilities), organizational capability, expertise, training, incentives and career structure, funding and collaboration with other sectors are such that they render the HCTS ineffective and inefficient.

To produce the **expected** results the HCTS must be given the **necessary** inputs. Figure 2 shows the typical inputs and expected outputs.

Committed government policy is a **prerequisite** for an adequate budget, planning programmes, spare parts, physical facilities, staff posts, career structure, etc. Having the required inputs is not enough to produce the desirable results, which are proper selection, specification and procurement of equipment, planning, inventory control, routine preventire maintenance, repairs and training of staff (user and service). Since many developing countries have no tradition or background in the servicing of equipment, their staff are unable to deliver quickly the expected results. Today's fast-changing electronics techology is not making matters easier.

The HCTS at central and provincial level should be able to carry out the following tasks:

- Identification of health needs
- Programming and planning of health interventions
- Policy, infrastructure and organization of HCTS
- Identification of needs in manpower, facilities, supplies, etc.
- Recruitment, promotion and assessment of staff
- Identification of equipment needs
- Financing policies for purchases and replacements
- Inventory control and updating
- Quality and safety control of equipment
- Control of imported equipment, sources and evaluation
- Equipment selection, specification, tendering, procurement
- Identification of training and retraining needs of users and technical staff
- Policy on spare parts and technical documentation
- Identification and planning of physical facilities and needs
- Requirements in routine maintenance, calibration and testing facilities
- Evaluation of private sector support
- Collaboration with other services and organizations

Thus, short-term and long-term programmes of manpower development and strengthening of service workshops should be designed and implemented to enable the HCTS to perform its tasks.

The main indicators of maintenance effectiveness of the HCTS are:

- Availability of service workshops at all levels (fully staffed and equipped with necessary transport support)
- Inventory at **Central, Provincial** and **Hospital** levels
- Planned Preventive Maintenance Programmes at all levels with necessary monitoring systems
- Adequate supply of common spare parts
- Full Technical Library at each workshop
- Selection of equipment by **Health Needs** and by means of a team approach
- Trained and experienced personnel
- Liaison with local and international market
- Availability of local training **within** national capabilities and needs
- Effective reporting system for repairs
- Low down-time of equipment
- Annual statistics relating to efficiency and effectiveness of service and equipment utilization

  Figure 3 shows a typical organization of a HCTS.

3.3 Inadequate Manpower Development and Training

The present lack of career structures, level of salaries, inadquacy of staff development and training for both **user** and **service** personnel at **all** levels of the health sector, including **technical managers**, inhibit human resources from fulfilling their responsibilities.

Manpower development should cover all levels of the service i.e. central, provincial, district and rural. The latter two should be provided for by National Training Centres (NTCs). These are still not widely found in developing countries and their establishment should be actively promoted.

National-level training programmes should:

- initially provide for Artisan and Polyvalent (General) Technician level (see Annex I)
- be within national capabilities and needs, commencing if necessary with expatriate assistance.

National Training Centres (NTC) should be situated in established technical institutions at central and, for very large countries, provincial level. However, the NTC should be very closely linked to a HCTS Central Maintenance Workshop situated in a large general hospital.

In this way the hospital (on-the-job) training may be carried out in a large hospital environment where students may be exposed to a large variety of problems.

International (regional or interregional) training is still required for higher level Specialized Technician, Assistant Engineer and Engineer training. Such centres exist already in some regions.

A comprehensive programme for these training centres should be established through WHO acting as a coordinating agency in order to establish the necessary transfer of expertise and training materials as well as establish the higher-level training, particularly for Engineer or Assistant Engineer, which is essential and at present cannot be undertaken at national level.

3.4 Insufficient Information Support

The present rapid technological changes require the availability of adequate and up-dated information for user, service and planning personnel. Of particular importance is information related to health-care equipment installation and commissioning, operating practices, safety standards, quality control, servicing, repairs, technical library and data, manufacturers and equipment information.

Trainers as well as HCTS staff need to have available the above up-to-date information concerning equipment in order to use it, **suitably modified and implemented**, for national needs. It is thus imperative that WHO acts as a coordinator and distributor of information of computer data banks, equipment codes, practices, safety and hazard notices, plant preventive maintenance procedures, etc.

To achieve this objective National Information Systems (NIS) need to be set up, which are capable of handling, adapting and assimilating such information and then ensuring that it is suitably implemented by the appropriate departments.

NIS may be situated within the NTC and thus both may form a National Training and Information Centre (NTIC), whose staff will provide both training and information support. In very large countries NTICs may be situated in provincial capitals as well as at central level. Among the main equipment needed for the NIS are a personal computer system and a heavy-duty photocopier, for storing information and also distributing it to the various health sectors and HCTS. Annex II shows a detailed breakdown of equipment for such a system.

To realize needs emanating from the use of high technology, to implement an effective and efficient HCTS and to provide adequate information transfer and support, a high calibre of trained and experienced staff is necessary. The required courses must therefore be organized at international level in order to make such training available to staff from developing countries.

4. Proposed strategy and aproach

To improve the present situation, and because of its inter-dependent and interactive nature, there is a need to strengthen, amongst other things, cooperation between HCTS and the local market, finance, medical stores, transport and logistic support system, medical and para-medical personnel, and customs procedures.

To address the four major obstacles mentioned earlier it is necessary to:

- Improve awareness, policy formulation, planning development and implementation;
- Strenghten HCTS effectiveness, efficiency and standard of service offered;
- Promote mechanisms to improve working and career conditions and offer adequate training to **all** levels of the health sector;
- Identify and implement the means of collecting, collating, assessing, disseminating and updating technical information.

5. Conclusions

The above suggestions are aimed at improving the management, maintenance and repair of health-care equipment. This is essential if the benefits in health care of technology are to be fully utilized for the improvement of health care delivery in developing countries.

6. Recommendations

To achieve the above, the following are necessary:

- Awareness seminars on policy formulation and planning development for HCTS technical managers and engineers;
- Strengthening or establishing service workshops at central, provincial and district hospitals with adequate staff, facilities and equipment capable of offering service support to rural and urban health units in their area;
- Strengthening or establishing National Training Centres to provide initially for the training of technicians for basic medical equipment, for national needs and within national capabilities;
- Establishing National Information Systems, using data-banks, capable of collecting, collating and disseminating technical information to interested parties within the health sector;
- Establishing national focal points to liaise with international agencies and manufacturers on matters concerning training, information transfer and bilateral agreements, equipment information and data;
- Establishing a standing policy and planning committee comprising members from **all** interested parties (medical, technical, user staff, finance, etc.) to oversee equipment and identify health needs;
- Strengthening regional and interregional training centres to enable them to offer training not available or envisaged in the near future at national level.

ANNEX I

Outiline Syllabus for a polyvalent technician course

Syllabus: Subject Matter

1. **English**

   Oral and Reading Skills, Grammar, Vocabulary, Technical English, Letter and Report Writing.

2. **Mathematics:**

   Computation, Logarithms, Trigonometry, Basic algebraic equations, Graphical representation.

3. **Technical Drawing**

   Use of technical drawing instruments, Elementary constructions, Pictorial projection, Sections, Electrical drawing, Visualization.

4. **Workshops**

   Electrical installations, theory and practice of wiring, domestic and industrial, selection of cables, lighting circuits, earthing systems, types of lamps. Principles and practice of: Arc welding, gas welding, Sheet metal, Plumbing. Bench Fitting; Use of files, hacksaw, chisels, drills and drilling. Threads, piping systems, workshop maintenance.

5. **Electronics and Electrotechnics**

   Electrical measurements, DC and AC circuits, Electrical components, Transformers, AC and DC motors, Semiconductors, Power supplies, Amplifiers, Applications of transistors, DIACS and TRIACS.

6. **Mechanical Services** (Hospital Plant)

   Heating and Hot Water Services, Refrigeration, Ventilation and Air conditioning, lubricants, standby generators, test vehicles repair and serving.

7. **Medical Equipment**

   Principles, operation and simple repairs and maintenance amongst the following equipment: Blood pressure meters, stethoscopes, water baths, microscopes, autoclaves, sterilizers trolleys, basic mechanical medical equipment, suction machines, centifuges, theatre lights, lamps, etc.

8. **Hospital Field Work**

   Field work in Hospital workshops under supervision, involving simple repairs and maintenance.

   Duration: One year

   Entrance Requirements: Candidates for the course should be graduates of a secondary technical school and preferably have some practical experience in a hospital workshop or technical service. Also a basic command of the English language would be an advantage.

ANNEX II

Requirements for a national information system

1. EQUIPMENT REQUIRED

1.1. Computer Hardware for Data Bank
One IBM (AT or equivalent) with 60 MB Hard Disk, 1.2M Floppy.
One Laser Printer
Fascimile (Telefax)
Heavy Duty Photocopier including Sorter, Auto-Feeder, Duplex, Editing, etc.
One MODEM to connect computer with telephone line.

1.2 Computer Software for Data Bank
Standard Data Base Package (to be adopted by WHO and other agencies).

2. RUNNING COSTS/YEAR

2.1. Rentals and consumablesfor Fax, Telex
2.2. Package and postage of materials to health sector and communication with reference centres abroad
2.3. Printer, Photocopy consumables and service
2.4. Administrative and secretarial support
2.5. Miscellaneous costs

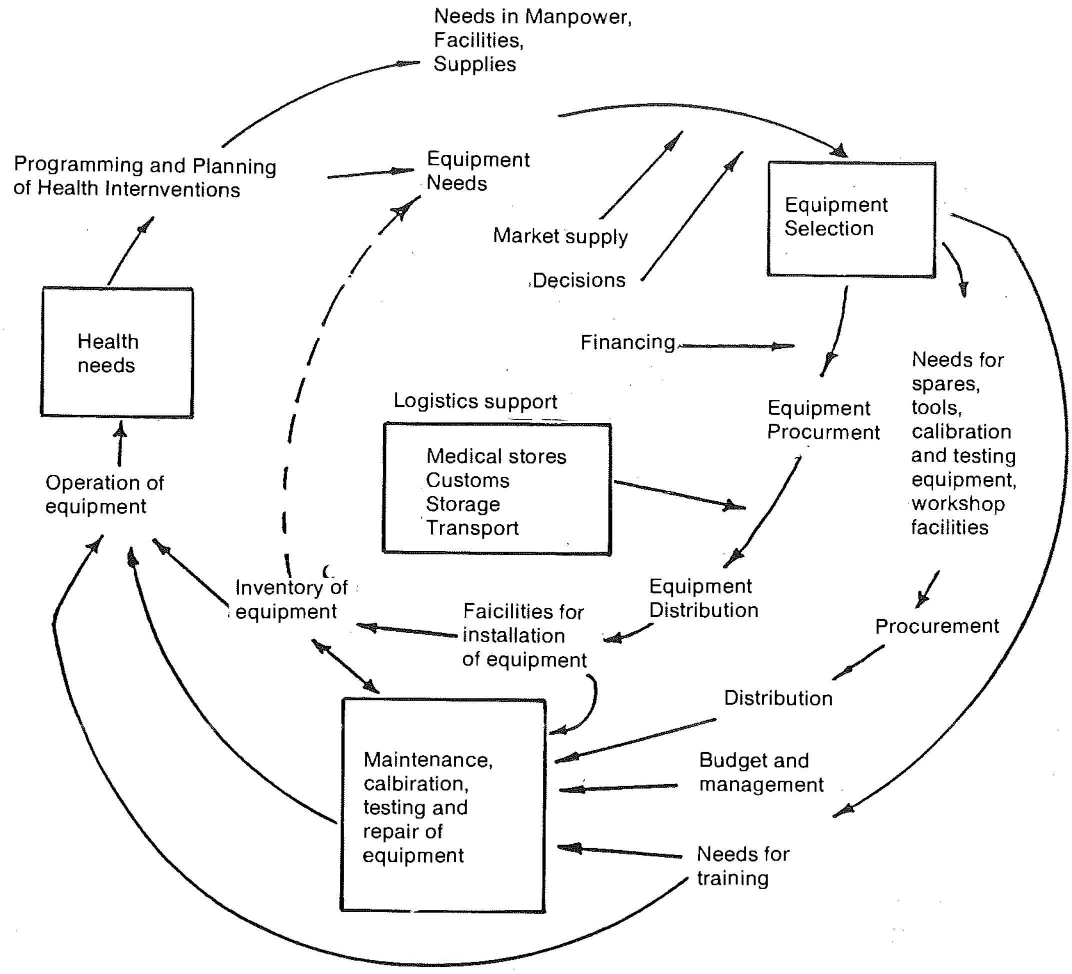


Figure 1: Cycle of Events Related to Management of Equipment

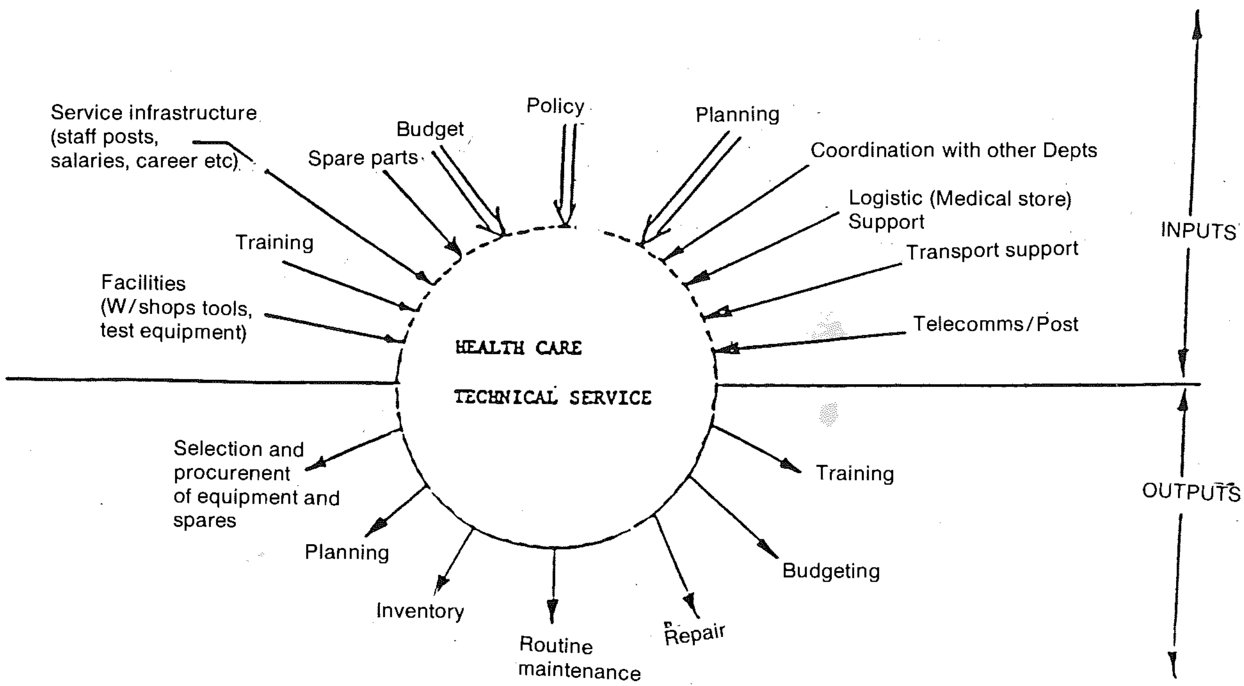
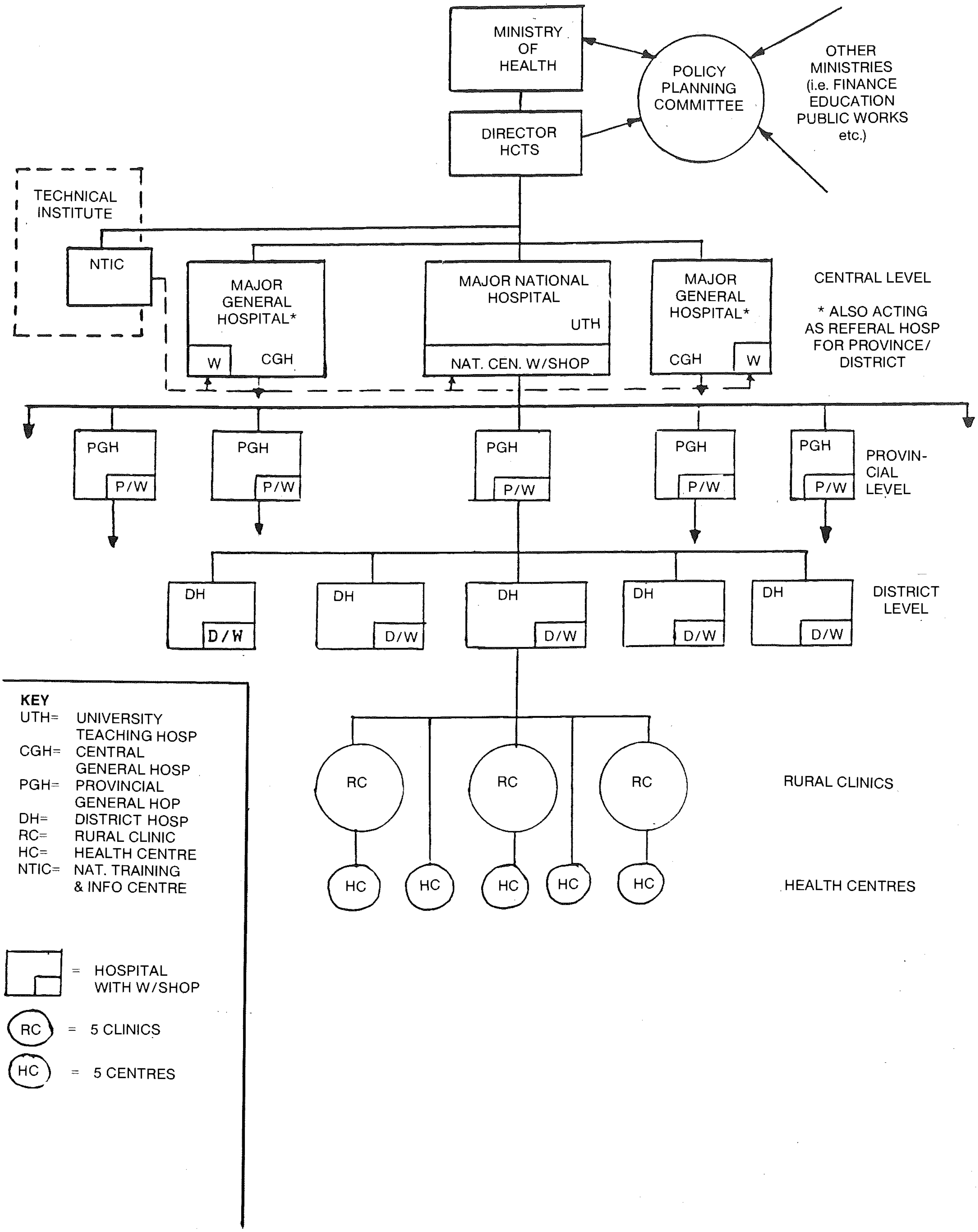


Figure 2_ HCTS System Inputs and Outputs

Figure 3: Typical HCTS Organisation Diagram



Beneficial and harmful effects of electricity, magnetism and non-ionising electromagnetic fields

A.K. Kaplanis MSc, MBES, AMIEE, F.I. Hosp. E
Lecturer, H.T.I.

This is a review article intended to arouse interest in Cyprus.

INTRODUCTION

The frequency spectrum of man-made and natural electromagnetic radiations ranges from d.c. to 3000 GHZ, although higher electromagnetic radiations include the Infra Red, Light waves and Ultra-violet waves, X-Rays Gamma Rays and Cosmic Rays.

It is well known that electromagnetic waves can have both beneficial as well as harmful effects on biological systems such as man, depending on the frequency, the field intensity, the duration of exposure and on the susceptibility of the individual.

Much research has been carried out and a lot more is still going on with no definite proof and concrete evidence regarding the theshold levels of intensity, frequency and exposure times of such fields beyond which these will have harmful effects on biological systems such as man.

Many contradicting scientific articles have appeared and a lot of discussion is going on amongst scientists, althouth it is generally accepted that such fields can be harmful under certain circumstances.

MAIN TOPIC

Beneficial biological effects of Electricity, Magnetism and Electromagnetic Fields on Man.

It is said that the first recorded case of a man to be cured of "pains of the gout", (arthritis), was a freeman of Nero, by the name of Anderos when he came in contact with a torpedo Fish, (electric fish).

This was reported by Scribonius Larcus in the year 47 A.D. and later by Dioscortides and Claudius Galen who recommended electroichthiotherapy for headaches.

This treatment persisted throughout the Middle Ages and in the 16th Century A.D., Duwad Al Antaki declared that the torpedo Fish "is efficacious in relieving chronic *headaches*, unilateral headackes and vertico even in desperate cases".

With the invention of electricity in the 17th Century AD several doctors and practitioners used electrostatic spheres and generators for therapeutic purposes. Some of their written reports, as given in publications obtained from the "Museum of Electricity in Life" are as follows:-

- *"... A Mr. Greenfield was reported to be dying of the gout of the stomach, but on observing the symptoms I was convinced that it was not the gout but angina pectoris ... I advised him to be electrified through the breast ... He was so. The violent symptoms immediatly ceased and he fell into a sweet sleep..."*

  [Note from the author. Needless to say of course that "electrification through the chest" was of low voltage shock from Leyden Jars]

- *"A man of Broomsgrove afflicted for a fortnight with a violent and constant headache, was twice electrified by a few light electric shocks with half an hour's interval and was entirely cured..."*

On magnetic field therapy there have been many claims and a German Jesuit Scholar in Medieval times, informs us in his publication "Magnetismus Medicinalium" that magnets have been used for therapeutic purposes well before the history of Ancient Greece.... in deep antiguity".

Some such claims, (out of many), are quoted herewith.

- *In the 4th Century AD a French Philosopher by the name of Marcel, recommends the use of magnets on necklaces for the relief of* headaches.
- *In the 6th Century AD, Alexander of Tralles employed magnets for the relief of pain in joints.*
- *In the 11th Century AD, Albertus Magnus claimed that magnets exercise powerful and therapeutic effects of many ailments.*
- *Abbe de Noble, Canon of Verseuil-Sur-Seine, having made a careful study of magnets in the treatment of many ailments and diseases sent his findings to the Royal Society of France who later employed two experts who "confirmed" the findings of de Noble.*
- *More recently, (1976), Professor Nakagawa of Japan is said to have used magnetic pellets of field strength 0.12 Tesla on almost twelve thousand patients suffering from Lumbaco, Neuralgia, Rheumatism etc, and found, with double blind tests, that 90% of the patients had had "... very efficient treatment".*
- *Dr. A.R. Davis and W. Rawls* found *that earth worms and other living organisms were full of activity and vitality when placed near the South Pole of a permanent magnet for 36 hours, but the reverse was true, (the living organisms were dying), when placed near the North Pole of the large permanent magnet.*

"Benefitial" Electromagnetic Fields

Apart from the numerous applications of medical equipment utilising electromagnetic waves for diagnostic purposes in Medicine, such as NMR imaging, C.T. scanning etc, electromagnetic fields are used for therapeutic purposes in Medicine. Some applications are mentioned.

- *Bone Healing.*
  Impressive results are claimed by many scientists and doctors using pulsed electromagnetic fields for bone-fracture healing and treatment of non-union tibia.
- *Soft Tissue Injuries*
  Short wave diathermy, utilising the Thermal Effects of such fields, (27MHZ), is said to be effective in the treatment of Soft-Tissue Injuries. (Effective healing has also been reported using athermal effects of electromagnetic fields).
- *... In the human body there exist groups of ions, (IONARS), as a result of diffusion and mechanical transport. These ionars are like sources of emfs which cause electron flow...*

  When tissue is damaged or injured, biologically closed electric circuits are activated, ion transport occurs, (electric current flows), and this flow of electric charges leads to structural modifications in tissue.

  This modification represents a result in the process of healing...

  Healing is achieved when the potential of the injured tissue is equal to the potential of the surrounding healthy tissue.

Dr. Bjorn Nordenstrom at the Karolinska Institute in Stockholm, author of an interesting book called Biologically Closed Electric Circuits, has succeeded in "shrinking" the size of 40 lung tumours, (of lost cases as he put it), by passing an electric current through them for a given time. [The writer has a relevant video cassette on the matter showing Prof. Bjorn Norderstrom at work and how he uses the techique of passing an electric current, at low voltage, for the purpose of reducing and "completely dissappearing" in some cases of lung tumours

The writer has also seen slides of Professor B.W. Watson's work whereby tumours in rabbits shrank and or dissappeared "using electronic techniques"].

Devices using pulsed electromagnetic fields are commercially available, claimed to be effective for the treatment of Lumbaco, Arthrytis, Burns, Laryngitis, Wound healing etc.

In a lecture given by Professor Nicolaos Ouzounoglou in Nicosia on the 3rd May 1990, invitees have heard that a technique known as hyperthermia utilizes microwaves for the teatment of tumours as well as for psychiatric diagnostics.

The technique is apparently relatively new and it is still on the experimental stage but results are encouraging.

Microwave frequencies of 432 M_{HZ}, 915M_{HZ} and 2450M_{HZ} have been mentioned.

"Harmful" effects of electricity, magnetism and electromagnetic fields

Everyone knows of course that electricity can be harmful and even fatal in biological systems such as man, if appreciable electric current flows through the body for a certain period of time.

Similarly strong, steady and low frequency (pulsed) magnetic fields of intensity greater than 1.5 Tesla are said to be harmful to biological systems in long exposures.

But many articles have been published and controversial, contradicting statements have been made by many scientists regarding the physiological and biological effects of ELF electromagnetic fields of lower intensities (and higher frequencies) in living systems.

Apart from man made electromagnetic fields there exist electromagnetic fields occuring in nature occupying recorded frequencies from 0.01H_Z to 100H_Z associated with Geomagnetic disturbances, weather disorders, electrical lightning discharges and possibly movements due to seismic disturbances.

Geomagnetic E.L.F. waves are almost sinusoidal in waveform, have electrical component intensities from slightly less than1mV/m to just 1V/m whilst their magnetic component is about 10 picoTesla and power intensities in the order of 0.01 microwatt/cm^2.

Researchers such as M.A. Persinger, H.W. Ludwig, K.P. Ossenkop and others carried out experiments and showed that these waves can propagate for long distances and can penetrate buildings and living tissue without appreciable attenuation.

The penetration of these waves in living tissue give potential strimuli and it is said, that the energy available from such waves can contribute to Neuro-Energetic functioning and Protein-Lipid activity.

According to several scientific reports and articles, electromagnetic fields can influence:-

- Oxygen uptake
- Cardiovascular Functions
- Precipitation-clotting times of colloids
- Ambulatory behaviour
- Endocrine changes
- Timing Behaviour
- Reaction Time
- EEG waves
- Mitogenesis
- Ability of T-lymphocyte cells to destroy cancer cells etc.

There seems to be a "frequency dependence" rather than intensity dependence in many experimental data. For example whilst a 50Hz or 60Hz electromagnetic field could inhibit the ability of T cells to kill cancer cells, fields at 42Hz of the same intensity are reported to delay the "taking of tumour graft".

Similarly microwave frequencies of 66, 71 and 73GHz were reported to slow the growth of cells whilst 68GHZ fields seem to stimulate the growth of cells.

There are several mechanisms by which electromagnetic fields might affect living tissue and animal behaviour. These mechanisms, it has been suggested, are based on:

Paramagnetic effects

Resonance effects (of the electrical and mechanical systems of cells and organs)

Neurovascular-Behavioral effects

In the case of paramagnetic effects the explanation is as follows:

Iron and oxygen in the blood are paramagnetic substances.

But paramagnetic substances are affected by the magnetic component of electromagnetic waves.

The energy from the magnetic component of the electromagnetic fields available to the paramagnetic ions and to oxygen molecules induce emfs thereby changing the inherent electrical characteristics of cells.

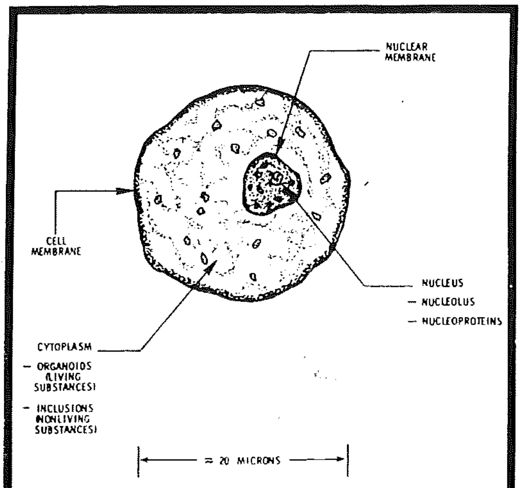
Well what are the inherent electrical characteristics of cells?

The human cell which is the building block of the human body exhibits an electrical potential of -90mV between compounds inside and outside of its semipermeabe membrane.

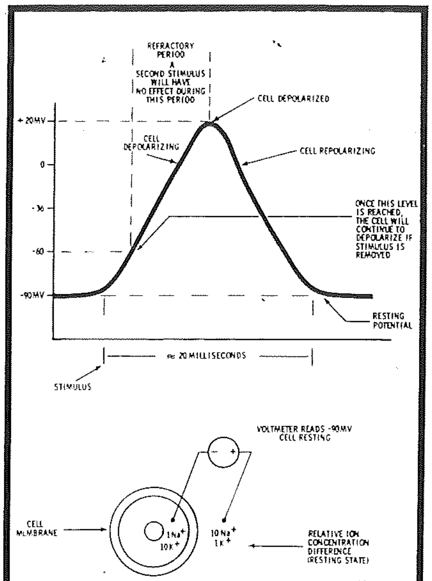
It has been found to possess capacitance in the order of pF depending on its size and c.s.a. and, as some scientists point out, the DNA molecule which is like a coil, possesses inductance.

In healthy cells there is a harmonious balance and imbalance of charges, resonating apparently at ultrahigh frequencies.

The sketches below show one kind of a typical 'average' human cell and its action potential when it receives a stimulus.



A typical "average" human cell



Action potential of the human cell

In cases of ill health the potential difference across the membrane of the cell is much less (-5 or even +5mV in the case of cancerous cells), and somehow they are said to be "completely off resonance" condition.

To sum it all up, man is a collection, a totality of his cells.

But cells are electromagnetic units and so electromagnetic wave radiations can and do influence the inherent electrical characteristics of cells, when the intensity of such fields is above a certain threshold level, other factors being, as already stated, the frequency, the duration of exposure and the susceptibility of the individual.

Here below are extracts from various articles, in summary, and the writer leaves it to the reader, to carry further investigations on the matter.

- *"Man has evolved in an environment flooded with electromagnetic radiation of all frequencies, but during the last century various highly coherent electromagnetic radiations have appeared in the environment. Living systems may utilize coherent oscillations for their own control purposes; thus there are many ways in which coherent oscillations in the environment may intefere with a living system to give rise to abnormal conditions."*
- *"... Cells communicate between them at microwave frequencies and biologically speaking microwaves are very important..."*
- *"... Fields resulting from microwaves modulated with extreemely low frequency (E.L.F) waves of 10 to 20 Hz have a profound influence on brain activity... By interfering with the passage of information between cells they could be implicated to cancer...."*

- *"... Living organisms such as rats, caught in a pulsed microwave beam ran about in desperate efforts to escape, became convalsed and died.*
- *"... I know it sounds horrible but electromagnetic waves can alter people's minds..."*
- *"... The Neurological complex behaves like a P.N Semiconductor since glial and neurosal membranes show an ordered structure of liguid crystals...*
  Electromagnetic waves may be amplified in living tissue under certain circumstances, similar to transistor semiconductors in radio sets..."
- *"... Energy is stored in active biological systems and this energy is available for release under certain circumstances...*
  The release of such energies may be triggered by a very small increase in energy, additional to the energy in the biological system or its environment...
  By analogy very weak signals reaching a radio receiver can trigger the release of large amounts of energy of acoustic power to the loudspeaker..."
- ***"... Living Cells are Electromagnetic units... Cancer is caused by increased electromagnetic activity of the cells.***
  By studying the activity of electrolytes, properties of protein/animo-acids as current carriers, the effects of enzymes as catalysts and the elecromagnetic effects of all electromagnetic and sound waves, heavy atoms and molecules as well as impurities of the environment on living cells, it can be shown theoretically and experimentally that cancer is caused by electromagnetic activity in cells...".

Perhaps a letter by Dr. Samuel Milham JR., (M.D.), of the Washington Department of Social and Health Services, to the editor of "The New England Journal of Medicine", (1976) is of some interest and concern. Extracts of the letter are mentioned.

"Mortality from leukemia in workers exposed to electrical and magnetic fields"

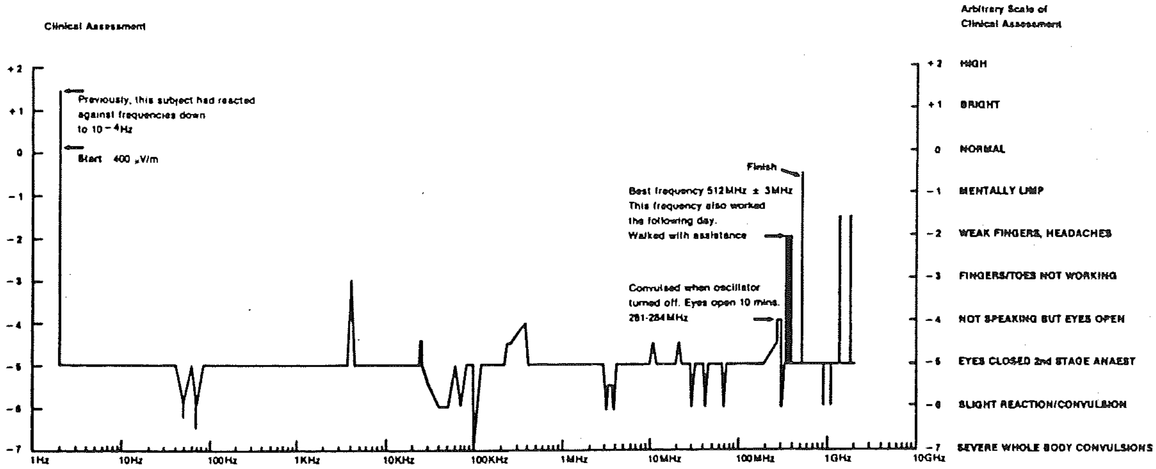
"To *the Editor:* In the course of updating a study of occupational mortality", I noticed that among men whose occupations required them to work in electrical or magnetic fields there were more deaths due to leukemia than would be expected.

All deaths of Washington State resident men 20 years old or older from 1950 through 1979werecoded to occupation. Proportionate mortality ratios standardized by age and year of death were calculated for 158 cause-of-death groups in each of 218 occupational classes. In all, 438,000 deaths were analysed...".

- *"... Using weak electromagnetic fields similar to those that leak from TVs and computers, we found certain frequencies that could trigger symptoms of allergic condition...*
  Sickness took the form of headaches, nausea, sweating pallor and indigestion..."
- *"... Some Allergic patients complain of extreme sensitivities to many man-made electrical, magnetic and electronic devices... Experiments have shown that there are real and objective effects as well as subjective effects...."*
- *"Extremely Low Frequency Fields are associated with modifications of subjective behaviour including consciousness..."*
- *"Some allergic patients may go unconscious when passing beneath overhead power lines..." (The figure below shows the Allergic Reactions of a patient S.L. as a function of frequency, as evidence of experiments carried out by Dr. C.W. Smith et al.).*

Dr, Cyril W. Smith states in his book "Electromagnetic man" that electromagnetic field strengths of E.L.F. waves, greater than 15nT could be hazardous especially to children.

The above extracts from some relevant articles available to the writer tend to imply that electromagnetic effects on biological living



The Allergic Reactions of Subject S.L. as a Function of Frequency systems could be harmful under certain circumstances.

To be fair however there are also many articles which contradict or speak of no harmful effects of such fields.

For example:

Dr. A.T. Barker and Dr. L.A. Coulton, both at the Royal Hallamshire Hospital in their talk under the title "Biological effects of low frequency electromagnetic fields - fourteen years of research at Shelheld", whilst recognising that there can be harmful effects of such fields, especially pulsed electromagnetic fields of intensity about 2 Tesla, they have serious reservations, (they do not agree), about claims for biological effects of these fields of much lower levels of intensity.

"... Epidemiological evidence has been adduced that fields of such strength can increase the chance of contracting leukaemia and in a separate study of committing suicide. These surveys are prliminary and unsatisfactory in various ways....
One follow up leukaemia study has failed to find any similar association".

Similarly a report from Electricite de France International regarding biological / physiological effects of electromagnetic fields states amongst other things the following:

"People living near transmission lines have never reported any adverse effect to their health. This is the reason why indepth studies into long-term effects of electric fields used to be considered unnecessary..
Research was carried out all over the world by doctors, biologists and engineers. It was based on the varied reactions of men and animals when subjected to very strong electric fields (170 kv/m)....

In non of the research carried out the world over, whether in labs or field studies on those living and working near electric lines, were any adverse side-effects found."

The same view is held by the Central Electricity Generating Board in the UK and they also announced a half a million pounds research project on ELF Electromagnetic field bio-effects which will involve studies of their own staff.

And yet all these again come in contradiction to the "results" and reports of other scientists such as Savitz, Perry, Wertheimer, Leeper, Smith, Choy, Monro and others.

So where do all the arguments, discussions and contradictions lead to.

Surely into the need for more and yet further research world wide.

But one thing is certain.

The cell, the building block of the human body exhibits electrical characteristics and as such it may be influenced by electric, magnetic and electromagnetic fields.

CONCLUSIONS:

There does not seem to be a consensus of opinion or consistency in the experiments carried out by many eminent scientists regarding the threshold levels of frequency and intensity of such fields and their correlation into possible ill-effects on humans. Is is clear however that Health Officials, scientists, doctors and even Electricity Authorities have come to realise and be concerned about the possibility of harmful biological and physiological effects from such fields and all work to identify the conditions under which such fields could be hazardous.

It is hoped that the co-operation of the Engineer, the Physicist, the Biologist, the Radiologist and the Doctor will lay down universally acceptable limits and recommendations for a healthier man and his environment.

REFERENCES

1. *The Bakken - A library and Museum of Electricity in life*
2. *Pulsed Magnetic field therapy for Tibial Non-Union by A.T. Barker et al.*
3. *The waves we all live in, by Ann Barr.*
4. *Living cells are electromagnetic units, by Reijo Makella.*
5. *Biologically Closed Electric Circuits, by Bjorn Nordenstron.*
6. *The New England Journal of Medicine (1976)*
7. *The Killer Electric, by Lowell Ponte*
8. *Electrical Sensitivities, in Allergy Patients, by Ray V.S. Choy, Jean Monvro, C.W. Smith.*
9. *Electrolytic changes in white mouse under the influence of weak magnetic fields, by A. Schober, M. Yanik and G. Fischer.*
10. *Tissue Interactions with Non-Ionizing Electromagnetic Fields, by A.R. Aden.*
11. *A system for investigating the in vitro effects of low frequency pulsed magnetic fields, by M.J. Lunt and B.W. Watson.*
12. *Biological effects of Extreemely Low Frequency Electrical Phenomena in the Atmosphrere by H. Konig*
13. *Physiological effects of extreemely low frequency electromagnetic fields, by M.A. Persinger, H.W. Ludwing and K.P. Ossenkopp.*
14. *Killing Fields, by Alasdair Philip, Simon Best & Roger Coghill.*
15. *Information about UHV Transmission Lines Electric Fields, Report from Electricité de France International.*
16. *Introduction to Medical Electronics, by Burton R. Klein.*
17. *Use of the healing power of Magnetism, by E. Holzaphel.*
18. *Electromagnetic man, by Dr. C.W. Smith and J. Best.*

Sonoluminescence and the medical ultrasound hazard

Stelios Christophides, Ph. D.,
Medical Physicist,
Medical Physics Department,
General Hospital Nicosia.

ABSTRACT

The use of medical ultrasound can be justified if it can be shown to provide only negligible or small risk while giving good benefit to the patient. This short article reviews sonoluminescence which is one of the mechanisms that induce harmful biological effects as a result of the indiscriminate use of medical ultrasound in therapeutic and diagnostic applications.

INTRODUCTION

The diagnostic methods committee of the British Institute of Radiology (BIR) meeting on 17 May 1984 noted that there was controversy relating to the safety of diagnostic ultrasound and recommended the setting up of a working group to review the scientific evidence[1]. The presidents of the Royal College of Obstetricians and Gynaecologists, the British Medical Ultrasound Society, the College of Radiographers and the Institute of Physical Sciences in Medicine accepted the invitation of the president of BIR to nominate experts to serve on the working group.

The conclusions and recommendations of the working group were:

(1) The extensive surveys of published and new information about exposure conditions used in contemporary ultrasonic techniques and the biological effects of ultrasound have failed to reveal any evidence that the present ultrasonic diagnostic practice carries any hazard due to ultrasound.

(2) It seems prudent to recommend that ultrasonic instruments should be designed to operate with exposure levels as low as reasonably practicable taking expense and diagnostic performance into account.

(3) The search for untoward bioeffects should continue in an orderly and planned fashion.

(4) Investigators who have assessed the health of children whose mothers were exposed to diagnostic ultrasound during their pregnancies should be encouraged to undertake follow-up studies provided that the exposure conditions are adequately documented and adequate numbers of children can be included to allow reliable and relevant results to be obtained.

Since the publication of this survey in 1987, a large number of invitro and invivo studies have been published giving the first evidence of biological effects due to diagnostic ultrasound[2,3,4] and confirming the biological effects due to therapeutic ultrasound[5,6,7].

SONOLUMINESCENCE

In order to understand the potential hazards of diagnostic and therapeutic ultrasound a background explanation is given here on one of the mechanisms of harmful biological effects, the process of sonoluminescence.

Sonoluminescence (SL)[8] is a weak emission of light that may occur when a liquid is cavitated by ultrasound, fast flow of liquids through a narrow constriction, mechanical shock waves and laser beams.

When SL is induced by ultrasound, the underlying mechanism can be summarized as follows: bubbles of suitable size within the liquid grow during the expansion phase of the sound cycle and subsequently collapse adiabatically during the compression phase thereby raising the temperature of the entrapped gas and vapour to several thousand Kelvin. The generation of high temperatures and associated formation of radicals is potentially capable of causing biological damage.

Three phases of bubble behaviour in the ultrasound field may be identified, namely formation, growth and collapse. The theoretical tensile strength of water at room temperature is in excess of 10^8 Pa which suggests that a sound field with a weak pressure amplitude of at least this order is required to induce cavitation accoustically. In practice cavitation phenomena are observed with peak pressure amplitudes of the order of 10^5 Pa, typical of the pressure amplitudes readily achievable with a 1 MHz continuous wave physiotherapy ultrasound machine between 0.1 and 1Ccm^{-2}. This implies the presence of pre-existing nuclei within a liquid. Since free bubbles float to the surface of the liquid, some mechanism of stabilization must be operating. The most favoured, supposes that a pocket of gas is trapped in a small angled crevice on a hydrophobic solid impurity. Tap water has been shown to contain many thousands of such particles per cubic centimetre.

The most prominent features of bubble growth may be summarized as follows:

(a) Bubbles may be gas filled, vapour filled or contain a mixture of both.

(b) In the absence of a sound field, the gas inside a bubble will gradually diffuse away because there is an excess pressure inside the bubble due to surface tension. The rate of loss will be higher if the surrounding liquid is not saturated with gas.

(c) In a sound field of sufficient pressure amplitude and several cycles in duration, the equilibrium radius of a bubble may increase by "rectified diffusion". This is explained as follows. If a bubble volume increases sufficiently during the rarefaction phase of the sound cycle, the internal pressure may fall below the external pressure and gas will diffuse into the bubble. During the compression phase the rate of loss of the gas is greater than at equilibrium. The rate of diffusion across the wall is proportional to the interfacial area, so for sufficiently large changes in volume more gas enters the expanded bubble when the surface area is large than leaves the compressed bubble when the surface area is small and, over a complete cycle, the bubble grows.

(d) The wall of a bubble of radius R at rest in an incompressible fluid and subjected to a sinusoidally varying pressure will resonate at a frequency characteristic of R. At other frequencies it will undergo forced oscillation. if the oscillations take place over a substantial number of cycles they are referred to as a stable cavitation.

(e) For certain pressure amplitude, bubble radius or ultrasound frequency, the bubble may grow through many cycles to several times its normal size and then collapse. This is transient cavitation. Collapse is more likely for bubbles of resonant size and during collapse, bubble wall movement may reach the speed of sound in the liquid and the bubble may disintegrate into many smaller bubbles.

Sonoluminescence is normally associated with transient cavitation and, because of the nature of the process involved, it is reasonable to assume that there will be a well defined threhold to the amplitude of the pressure excess at which it will occur. This threshold, however, is very dependant on the gaseous state of the medium and also on the duration of the sound wave, since both the number and the size of bubbles change during exposure to sound.

Regarding the origins of sonoluminescence, the initial mechanism is undoubtedly thermal and results from adiabatic heating as the bubble collapses in a time of the order of 1 μs. The SL spectrum of Xenon saturated water can be fitted tolerably well to that of a black body at 6000 K in the range 400-600 nm.

Thus the model is one in which the bubbles transform from the relatively low energy density of a sound field into a very high energy density by absorbing energy from the sound wave over one or more cycles and expelling it over a very short time interval. Under appropriate conditions the energy is converted into radicals and light is emitted.

The similarity to the mechanism of energy deposition by ionising radiation is clear and the rates of free radical production achievable with ultrasound in water are equivalent to dose rates of ionising radiation of several Gray per second. Since SL is mainly associated with transient cavitation, emission of light may be taken to indicate the possibility of a biological hazard.

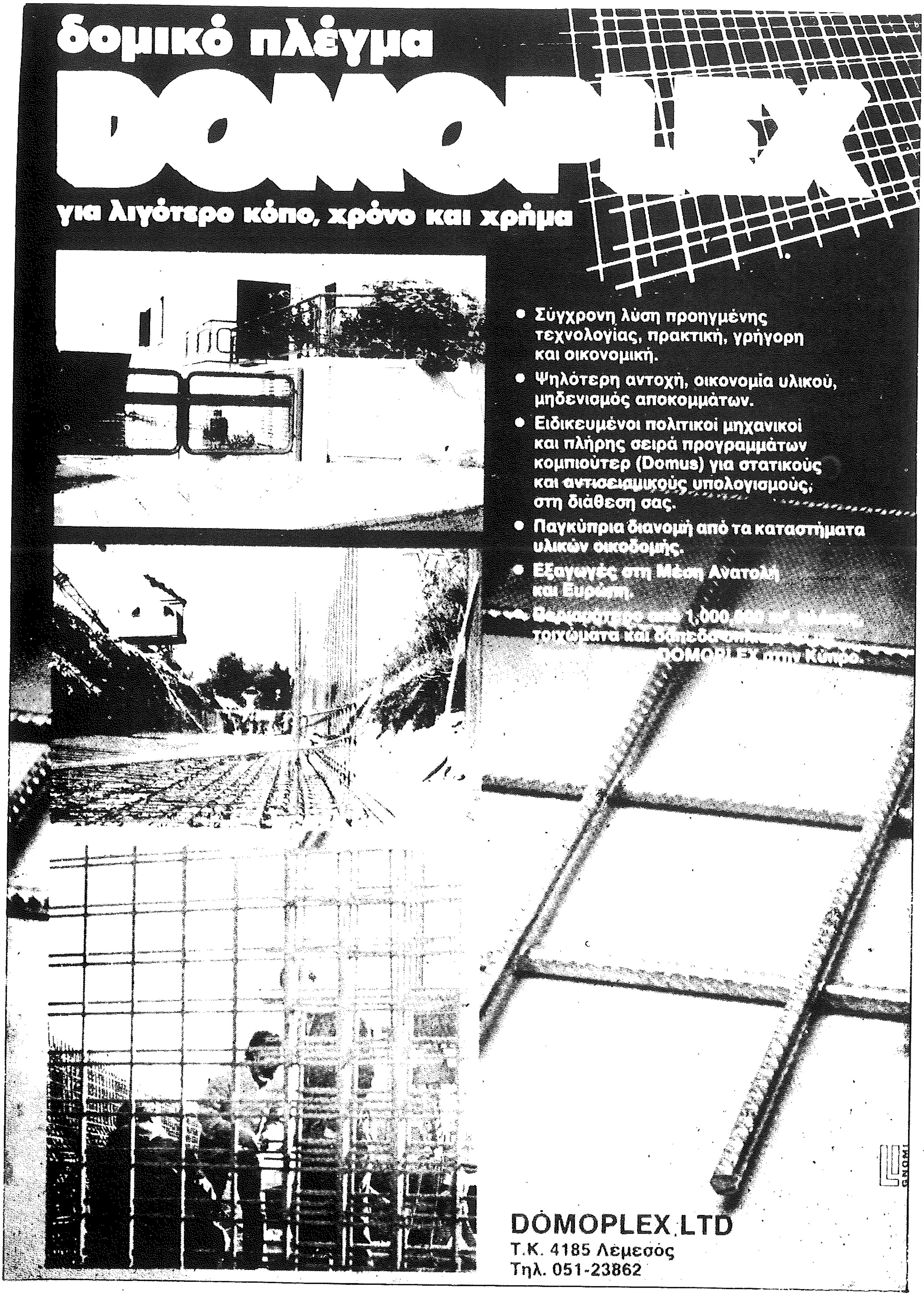
CONCLUSION

In view of the facts presented above and in view of the increasing evidence reported elsewhere for the possible hazards that may be involved in diagnostic ultrasound and the hazards that are involved in therapeutic ultrasound it is concluded that careful calibration, quality control and quality assurance programmes must be introduced in the fields of diagnostic and therapeutic ultrasound.

The choice of the physician for ultrasonic techniques in diagnosis and treatment should be justified by the results it will produce in a similar manner as ionising radiation techniques are justified.

REFERENCES

1. *"The safety of diagnostic ultrasound", British Journal of Radiology, Supplement No. 20, London 1987.*
2. *LW Anson, RC Chivers, "Ultrasonic propagation in mammalian cell suspensions based on a shell model", Physics in Medicine and Biology, Vol. 34, No. 9, pp 1153-1167, 1989.*
3. *MJW Pickworth, et al, "Studies of the cavitational effects of clinical ultrasound by sonoluminescence: 3. Cavitation from pulses a few microseconds in length.", Physics in Medicine and Biology, Vol. 34, No. 9, pp 1139-1151, 1989.*
4. *MA Dinno et al, "The significance of membrane changes in the safe and effective use of therapeutic and diagnostic ultrasound.", Physics in Medicine and Biology, Vol. 34, No. 11, pp 1543-1552, 1989.*
5. *TG Leighton, et al, "Studies of the cavitational effects of clinical ultrasound by sonoluminescence:1. Correlation of sonoluminescence with the standing wave pattern in an acoustic field produced by a therapeutic unit.", Physics in Medicine and Biology, Vol. 33, No. 11, pp 1239-1248, 1988.*
6. *MJW Pickworth et al, "Studies of the cavitational effects of clinical ultrasound by sonoluminescence:2. Thresholds for sonoluminescence from a therapeutic ultrasound beam and the effect of temperature and duty cycle.", Physics in Medicine and Biology, Vol. 33, No. 11, pp 1249-1260, 1988.*
7. *MJW Pickworth et al, "Studies of the cavitational effects of clinical ultrasound by sonoluminescence:4. The effect of therapeutic ultrasound on cells in monolayer culture in a standing wave field.", Physics in Medicine and Biology, Vol. 34, No. 11, pp 1553-1560, 1989.*
8. *PP Dendy, "Sonoluminescence and the ultrasound hazard debate", Physics in Medicine and Biology, Vol. 33, No. 11, pp 1233-1237, 1988.*


δομικό πλέγμα
DOMOPLEX
για λιγότερο κόπο, χρόνο και χρήμα
• Σύγχρονη λύση προηγμένης τεχνολογίας, πρακτική, γρήγορη και οικονομική.
• Ψηλότερη αντοχή, οικονομία υλικού, μηδενισμός αποκομμάτων.
• Ειδικευμένοι πολιτικοί μηχανικοί και πλήρης σειρά προγραμμάτων κομπιούτερ (Domus) για στατικούς και αντισεισμικούς υπολογισμούς, στη διάθεση σας.
• Παγκύπρια διανομή από τα καταστήματα υλικών οικοδομής.
• Εξαγωγές στη Μέση Ανατολή και Ευρώπη.
1,000,000
τοιχώματα και
DOMOPLEX στην Κύπρο.
DOMOPLEX LTD
Τ.Κ. 4185 Λεμεσός
Τηλ. 051-23862

Explosive forming as an industrial process

L.G. Lazari, BSc., PhD, M.I.Exp.E.

INDTRODUCTION

More often than not explosives are associated with destruction rather than their usefulness as a unique form of energy. Many scientists however have spent a considerable time in investigating the interaction between explosives and metals as a result of which, explosives can be used today in a controlled manner in the following metal working processes:

a) Explosive Forming of Sheets and Plates
b) Explosive Bulging and Swaging of Tubes
c) Explosive Punching and Shearing
d) Explosive Engraving
e) Explosive Hardening
f) Explosive Welding
g) Explosive Powder Compaction

The explosive forming process has found many and varied applications[1] and has been used for a wide Variety of metals. Metal components have been formed by this method out of aluminium alloys, carbon and alloy steels, titanium and refractory metals.

Depending on the size and accuracy of the component to be formed, the process of explosive forming with or without a die can be employed.

THE MECHANICS OF EXPLOSIVE FORMING

In this analysis, let us consider the explosive forming of parabolic dishes using a die as shown in Fig. 1.

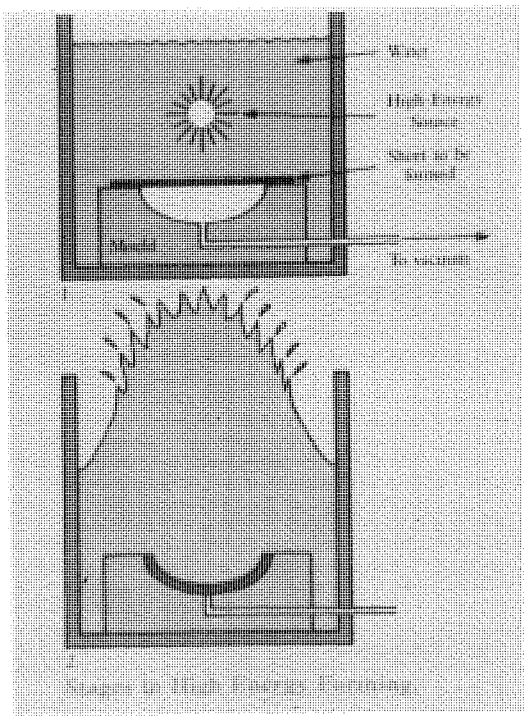


Fig. 1 Explosive forming of parabolic dishes using a die.

The blank and die are immersed in a water tank with the explosive charge situated at the centre and a small distance away from the blank. The pressure pulse generated by the detonating charge expands outward through the water medium in a spherical form. The peak pressure at the expanding wave-front decreases with time and thus reducing the unit impulse available for useful work.

At any given distance from the centre of the charge, the pulse will have a pressure-time profile[2] of the type shown in Fig. 2, and which can be represented by the expression,

$$P = P_m e^{-\frac{t}{\theta}} \qquad (1)$$

where P is pressure as a function of time,
P_m is the peak pressure at that distance,
t is the time after arrival of the front and
θ is the time constant characteristic of the charge weight, type of explosive and distance from the charge. It represents the time that it takes the pressure to fall to 1 / e of its peak value. θ has the same time units as t.

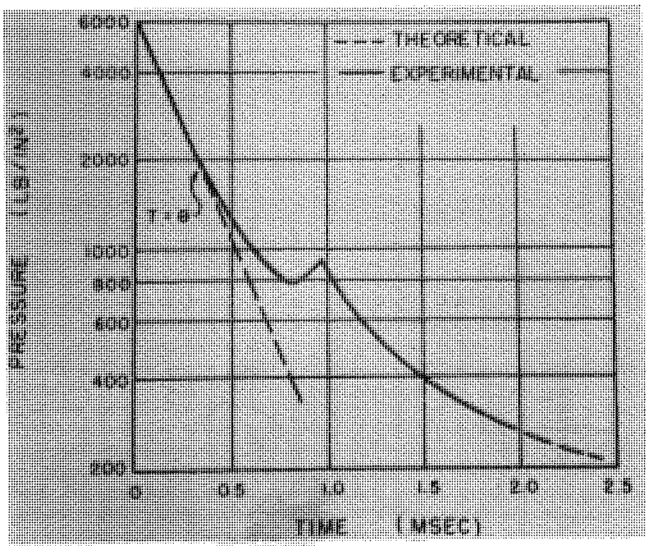


Fig. 2 Pressure-Time profile of an underwater explosion.

The peak pressure, impulse and energy associated with the pressure pulse can be estimated from the following empirical equations:

$$P_m = A\left(\frac{W^{1/3}}{R}\right)^{\alpha} \qquad (2)$$

$$I = BW^{1/3}\left(\frac{W^{1/3}}{R}\right)^{\beta} \qquad (3)$$

$$E = CW^{1/3}\left(\frac{W^{1/3}}{R}\right)^{\gamma} \qquad (4)$$

where P_m is the peak pressure. I is the impulse, and E is the energy flux passing through a unit area of a fixed surface lying normal to the direction of propagation of the wave-front. When the explosive constants A, B, C, α, β and γ are as given in Table 1, the standoff distance R is given in feet and the charge weight is given in pounds, then P_m is in P_{si}, I is in lb-sec/in^2, and E is in in-lb/in^2. The values of I and E as given are actually effective unit impulse and effective unit energy flux density, respectively, since both are given in terms of one square inch of area, and the explosive constants are based on an integration over an effective time limit.

Table 1

Explosive	Peak Pressure, P_m		Impulse I(t)		Energy density, E(t)	
	A	α	B	β	C	γ
TNT[a]	21,600	1.13	1.46	0.89	2,410	2.05
Loose Tetryl[b]	21,400	1.15	1.73	0.98	3,000	2.10
Pentolite[c]	22,500	1.13	2.18	1.05	3,270	2.12

[a] Density = 1.52 gm/cc, integration time = 6.7θ.
[b] Density = 0.93 gm/cc, integration time = 5.0θ.
[c] Density = 1.60 gm/cc, integration time = 6.7θ.

By considering the strain energy required to deform the blank to a parabolic dish the size of the explosive charge can be estimated[(3)].

EXPLOSIVE FORMING USING A DIE

As shown in Fig. 3 a die may be used for the manufacture of complex shapes to a very high accuracy.

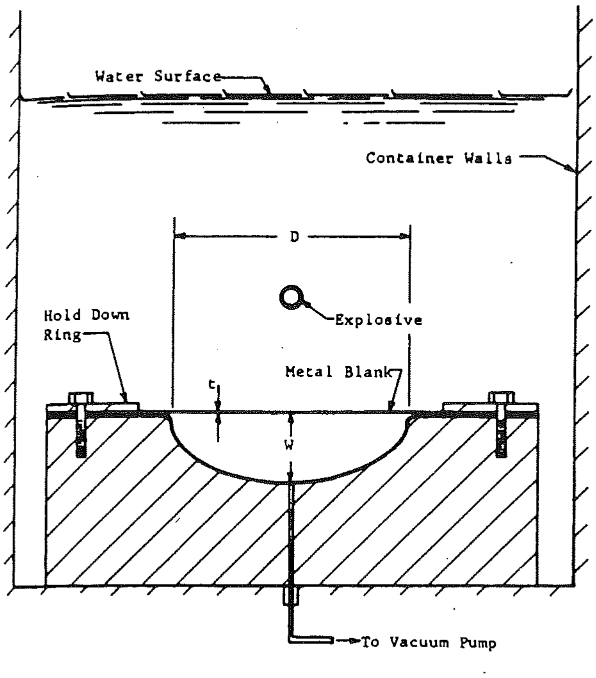


Fig. 3 Explosive forming using a die.

The blank is placed on top of the die with a rubber seal between the blank and the die. The blank is held against the die using a hold down ring which is bolted onto the die. The small hole (2-3 mm) at the bottom of the die is used to evacuate the system and allow the blank to be projected and formed into the die against no air resistance.

The explosive charge is a water resistant explosive with a detonation velocity of 6000 to 8000 m/s. It is moulded into a spherical shape and placed at the centre but a small distance (50-200 mm depending on the size of the blank) above the blank. The system is then lowered into a water tank and after evacuating the die, the charge is detonated and the blank is forced to take the shape of the die. The "hold down" ring mentioned earlier, prevents the blank from wrinkling at the edges.

This process is generally used for the production of components of moderate sizes and of high accuracy. Such components are, parabolic dishes for telecommunications systems (Fig. 4).

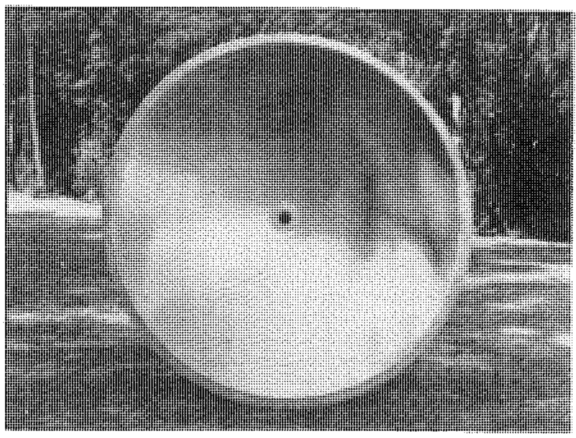


Fig. 4 Parabolic dish, 1.8 m in diameter, 3 mm thickness, formed from commercially pure aluminium using a die.

North American Aviation have explosively formed large gore segments for 3 m diameter pressure vessel bulk heads (Fig. 5).

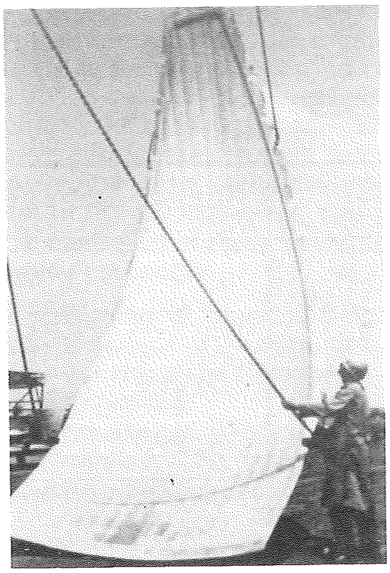


Fig. 5 Explosively formed gore segments from 2014-0 Aluminium for 10m diameter bulk head.

The Martin Company has produced, explosively formed prototype domes of 2014 aluminium, 3m in diameter on the Titan II progrmme (Fig. 6) and has been explosively forming 1.5m domes on a production basis.

Fig. 6 Explosively formed domes, 3 m in diameter from 2014-0 Aluminium.

The explosive forming process using a die has also being used on a regular basis by the Foster-Wheeler Corporation to form heat exchanger components (Fig. 7).

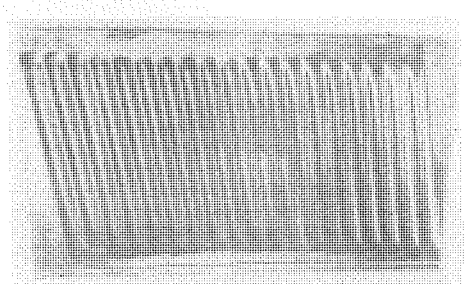


Fig. 7 Explosively formed boiler roof panel.

Furthermore the Rayan Company has been producing aluminium reflectors using this revolutionary technique (Fig. 8).

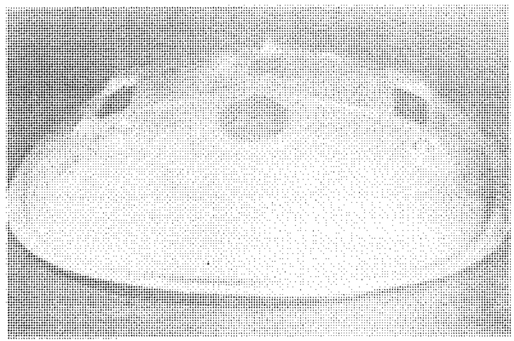


Fig. 8 Explosively formed Aluminium reflector.

The explosive bulging and Swaging of tubes using a die has also proved to be a fruitful application of explosive forming techniques. An example of explosive tube bulging by North American Aviation for the purpose of providing a local change of cross section in a large duct for the Suturn launch vehicle in shown in Fig. 9.

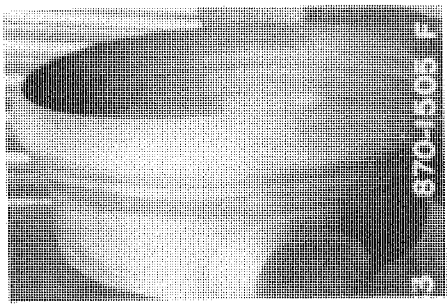


Fig. 9 Explosive tube bulging.

The explosive expansion of tubes has also found commercial applications[2] in fitting heat exchanger tubes very tichtly into tube plates (Fig. 10) and in the production of hollow truncated cones and pipe reducers.

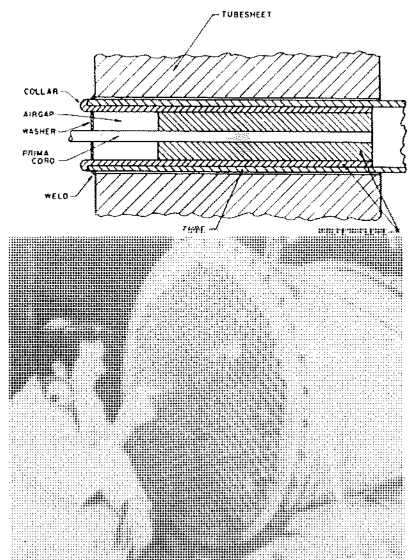


Fig. 10 (a)(b). Tube to tube plate tight fitting by explosive expansion.

Basically there are no limitations on the explosive forming process using a die other than the sometimes excessive cost of the die and the number of components to be produced.

EXPLOSIVE FORMING WITHOUT A DIE

This technique elliminates the use of highly accurate and expensive dies and employs a simple set-up, shown in Fig. 11.

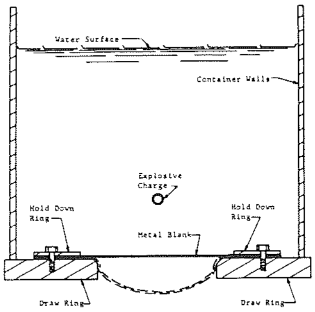


Fig. 11 Explosive forming without a die.

The blank in this case is placed on top of the "draw ring" which is made with a radius of curvature 5 times the thickness of the blank. The blank is held down the same way as before and water is used again as the energy transmission medium.

This technique has been particularly useful in the production of hemispherical bulk-heads[4] 3m in diameter for the construction of large rocket fuel tanks (Fig. 12).

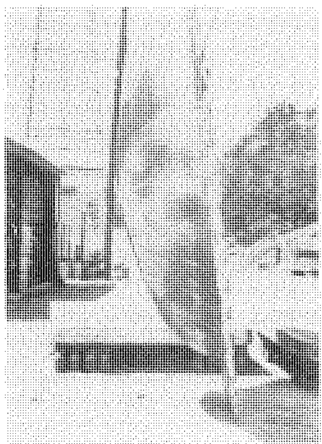


Fig. 12 Elliptical domes, 3 m in diameter.

Fabrication of these domes in one piece by conventional punch and die operations would require large and prohibitively costly tooling. Even then, the feasibility of forming acceptable domes of high strength aluminium alloys such as 2014 would be questionable.

These domes are fabricated at Martin Company's Denver Division in "orange peel" sections and then weld them together. The heat affected areas adjecent to the welds because of lower strength require an additional safety factor to be included into the entire domes with undesirable weight being added.

All these problems can be avoided by explosively forming these parts in one piece, cheaply and reliably, and thus, reducing their weight and eliminating numerous areas of protential failure.

Elliptical mild steel domes 300mm in diameter, 3mm thick were explosively formed without a die on experimental basis by the author here in Cyprus. These tests were carried out at the "Mitsero Quarry" of the Hellenic Mining Company with astonishing success. These ellptical domes can be used for the production of hot water high pressure cylinders, large capacity gas cylinders and fuel storage tanks.

CONCLUSIONS

Explosive forming is a versatile process which has found numerous applications ranging from the aerospace industry to the nuclear, chemical and petroleum industries.

It is a particularly useful process for the production of complex shapes using metal alloys which are not easily formed by conventional metal forming techniques. For the production of relatively small components in large numbers explosive forming dies must be used, however, for large components in small numbers the high cost of the dies is not justified and explosive forming without a die is used.

It is a relatively cost effective process but unsuitable for mass production.

REFERENCES

1. *RINEHART J.S. AND PEARSON J., "Explosive Working of Metals", Pergamon Press, LONDON, 1963.*
2. *LAZARI L.G., PhD Thesis, "The Explosive Welding of Multilaminate Composites", U.M.I.S.T, 1986.*
3. *EZRA A.A., "Principles and Practice of Explosive Metal Working", Industrial Newspapers Limited, London, Volume 1, 1973.*
4. *ASTME, "High Energy Rate Forming", Book 3, U.S.A, 1963.*

Antimatter and its applications

A.Z. Achillides
Senior Lecturer HTI

Antimatter:

The idea that antiparticles should exist came from Paul Dirac's theoretical work in 1920. He postulated that a "type" of matter may be found which was the exact mirror of ordinary matter in all its properties. For example the mirror image of an electron which is negatively charged is a particle of the same mass but of opposite charge called positron. A few years later two American scientists R. Millikan and C. Anderson did indeed discover positrons in the debris from collisions of Cosmic rays with the atoms in the upper atmosphere. More than 20 years later a group of researchers led by E. Segre in the university of California at Berkeley discovered the antiproton, or to be more precise that created it out of energy in a particle accelerator. By bombarding a metal foil with protons of energy more than a billion eV E. Segre and his colleaques managed to condense the energy into a trickle of antiprotons.

We now know that every fundamental particle has an antimatter partner. When they meet they react violently annihilating each other with a huge burst of energy.

Physicists now build and use particle accelerators to smash particles of anti matter and matter against each other, positrons against electrons, antiprotons against protons to produce more exotic particles, that are supposed to tell us something about the fundamental nature of the universe.

The discovery of antiparticles

The positron was the first particle to be discovered among the Cosmic ray showers in 1930 by C. Anderson and S. Neddenmeyer. The Cosmic rays which are energetic particles coming from outer space bombard continuously the atmosphere producing secondary particles and matter antimatter particles. In their detecting chamber Anderson and Neddermeyer found tracks of what looked like electrons but which were deflected by the strong magnetic field surrounding the chamber in the opposite sense from that expected. These positively charged electrons were later on called positrons. Later on it was found that matter-antimatter production plays a key role in the propagation of the so called "Cosmic ray showers" through the atmosphere the showers being generated by just one primary particle. What is probably happening is that a cosmic ray particle ie. a proton for example hits an oxygen or nitrogen nucleus in the atmospheric and generates many particles called mesons.

The neutral ones (Pi-zero particles) decay spontaneously into two γ-ray photons and these then produce electron - positron pairs. These thus annihilate producing in turn more γ-ray photons and the process continues as a cascade. As an aside the biggest cosmic ray showers to be observed containing many billions of particles (mainly e^+, e^-) have been detected at a great extensive air shower array run by a consortium of British Universities at Haverah Park near Harrogate in Yorkshire.

There is a much greater difficulty to generate antiprotons due to the high energy needed, concequently are few in number and very difficult to detect them in the Cosmic radiation. Although tentative claims had been made from cosmic ray searches it was until the development of energetic accelerators that a firm claim could be made. Chamberlain and colleaques were credited with their discovery in 1955 using a particle accelerator at Berkeley in California.

Antimatter and Cosmology;

The question of the extent to which there is antimatter in the Universe is a fundamental one for Cosmology. Judging by the success of many conservation laws it was expected that there would be equal amounts of matter and antimatter after the Big-Bang.

However if this were the case then in the very early stages of the Big-Bang there would have been such a tremendous amount of annihilation that there would have been virtually no mass left (of matter or antimatter) to give us the stars and galaxies that exist to day. Until recently the argument was that a tiny excess of matter over antimatter was present in the begining (about one part per billion) and this persisted to give the Universe we see today. The rest of the matter and antimatter annihilated each other to produce photons of radiation. The fact that photons presently outnumber baryons (heavy particles like protons and neutrons) by about a billion to one implies that only one particle in a billion survived the mutual destruction of matter and antimatter which took place as the Universe cooled.

More recently with the advent of the Grand Unified Theory (GUT) it has been suggested that perhaps there was equality between matter and antimatter in the beginning but the so called baryon number is not conserved and particles of matter and antimatter decayed in slightly different ways under the incredibly hot conditions of the first tiny fraction of a second after the Big-Bang with the result that only some of the matter survived and none of the antimatter.

In both of these "theories" the Universe as we see it now is composed of matter the odd particles of antimatter seen only in Cosmic rays having been produced together with their twin matter particles by occasional recent phenomena.

Another interesting theory was proposed by Omnes and others. According to this theory there was an equal production of matter and antimatter at the very-very beginning and much of it became separated very early on before annihilation really got going so that antistars and antigalaxies are every about in the vastness of the Universe. This fundamental question will possibly be answered using the forthcoming U.S space station. A group of scientists are currently examining the possibility of mounting a so called Particle astrophysics magnet spectrometer (ASTROMAT) on the space station which will measure the charge and momenta of Cosmic ray particles with an incredible precision and that possibly many more new antiparticles may be recorded. The discovery of antinuclei above that of hydrogen ie Carbon or Iron for example will be the solid proof of the existence of antistars and antigalaxies because although antiprotons can be produced in various ways the anti heavy nuclei such as anti-Iron can only be generated in essentially no other way. Here then is the "Holy Grail" of the Cosmic ray physicists, the search for the anti heavy nucleus.

With antimatter to the stars

Antimatter is not just a fictional fuel powering the starship "Enterprise" in the famous T.V. Series "Star Trek". In fact the US Air force is looking at the possibility of using antimatter as a source of energy for space propulsion. If this and other current research bears fruit we may find ourselves entering an era of a new technology, the antimatteer technology. This may give us the tools to colonise the Solar system.

But what kind of energy would antimatter produce.[2] When an electron and positron annihilate their mass is converted directly into γ-ray photons as shown in fig. 1(a).

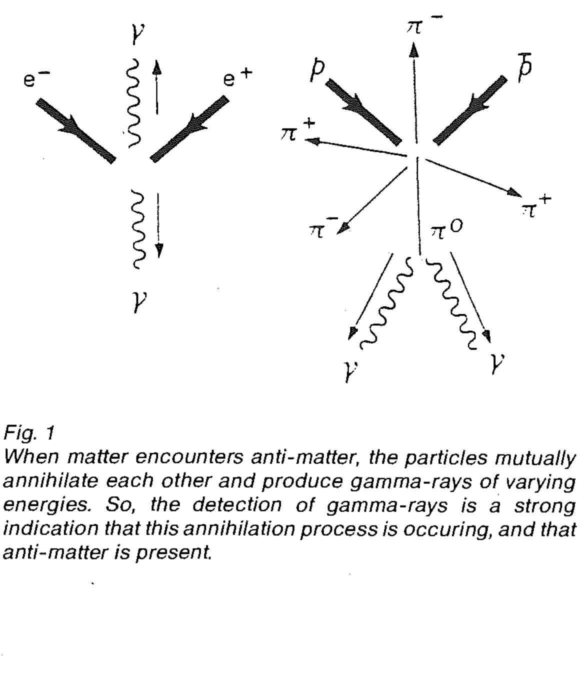


Fig. 1
When matter encounters anti-matter, the particles mutually annihilate each other and produce gamma-rays of varying energies. So, the detection of gamma-rays is a strong indication that this annihilation process is occuring, and that anti-matter is present.

On the other hand the annihilation of a proton and antiproton is more complicated fig. 1 (b). This is because protons and antiprotons are complex particles made of three more fundamental particles called quarks. Proton-antiproton annihilation first produces γ-rays and another kind of subatomic particle made of two quarks, the pion. Some of the pions produced are electrically charged and others are neutral. The pions are unstable and after a very short instant of time (2.6×10^{-8} s) they decay into positrons and electrons which in turn meet and annihilate producing γ ray photons.

Gamma rays (γ-rays) are very energetic and very dangerous to human beings. Apart from this they are not very useful for providing power because it is a very difficult job to focus them. However the charged pions produced by the annibilation of protons antiprotons are offering more attractive possibilities as a power source because using appropriate magnetic fields it is possible to change their paths in any direction and subsequently their kinetic energy can be turned into heat energy and useful power. There are however two major problems with using antimatter as a source of energy.

The first has to do with Physics and the second with economics. At present producing antimatter is far more expensive than exploiting the conventional sources of energy like fossil, fuels, water energy and nuclear fission that we rely on today.

Simple calculations will show that the production of even a minute amount of antimatter requires an enormous amount of energy since the production of a pair of proton antiproton requires 10^{12} eV which is at least 250 times as much energy to make the antiproton than we will ever get out of it from the annihilation. The second problem is one of accelerators used now to make antimatter are incredibly inefficient. They only produce minute quantities of antimatter whose proportion to ordinary matter range for one part per million in Soviet accelerators to few parts per thousand million in the machines at CERN, the European center for high energy Physics. Today it costs as much as a thousand billion dollars to make a microgram (10^{-9} kg) of antimatter!! To reduce costs one practical solution is the development of antimatter factories expressly designed to produce antimatter efficiently at about 0.01 per cent instead of the today efficiency amounting to 0.000 0001 per cent. Such factories will provide antimatter at about a million dollar per microgram.

Although antimatter seems unsuitable for propulsion on earth for various reasons it might be an ideal fuel for rockets. As early as the 1950s Eugene Sanger, the German rocket scientist proposed a "photon rocket". Its thrust came from γ-rays produced by electron positron annihilation. The rocket however would require some kind of science fictional electron gas mirror to focus the γ-rays for thrust. Unfortunately for us Sanger never found a way to do such a thing.

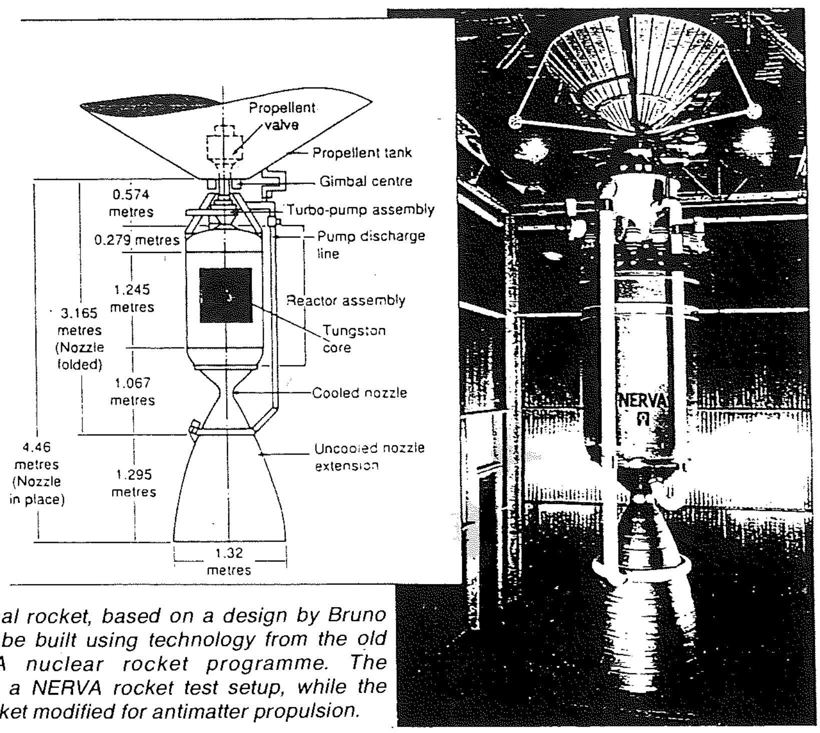
The discovery of antiproton however changed the situation. If we could make and store as much as a milligram of antiprotons then they could be used as a highly efficient source of energy for rocket propulsion. There are at least two different ways of using charged pions from antiproton annihilation for space propulsion. In a well designed antimatter propulsion system a powerful magnetic field can contain most of the charged pions in the engine and then direct them at the rear to provide thrust for the rocket.

A better way to use the charged pions is to pass them through a "working fluid" such as water, methane or liquid hydrogen. The electrical charge on the pions will interact with the electrons in the atoms of the gas or liquid transfering energy to the working fluid and heating it up. The working fluid passes through the rocket nozzle streaming out in one direction and the rocket will move off in the opposite direction. It was calculated that 30-50 per-cent of the annihilation energy is transformed intc kinetic energy of the rocket exhaust.

The storing of antimatter and controlled annihilation was studied by J. Gaines of the university of Hawaii who suggested to store antiprotons as an iceball of antihydrogen which is a combination of an antiproton and positron. No one has yet succeeded in making antihydrogen but it is feasible. He further concluded that an antihydrogen iceball weighing 10 milligrams could withstand 300 annihilations per second happening on its surface without exploding if it were maintained at a temperature of 2 K in a container with walls held at 1 K. Gaine's calculations are backed by considerable experimental data showing that samples of radioactive tritium. (Isotope of hydrogen) cause very little heating in solid hydrogen. The same would be true of annihilations on the surface of an antihydrogen iceball.

An iceball of antihydrogen would allow quantities of antimatter useful for space propulsion to be stored transported and used without fear of either annihilation explosion or even excessive loss of valuable antihydrogen. The very low temperatures required present are routinely created and maintained in most research laboratories.

A simple antimatter rocket has been designed by Bruno Augestein at the Rand Corporation in California. It is called a "tungsten thermal core antimatter plant". The Augestein's antimatter propulsion system consists of a block of tungsten metal. The block is porous so that a 'working fluid' such as liquid hydrogen or water can truckle through it. The tungsten block also has a large hollow space in its centre. Tubes and pipes drill in it allow separate streams of antiprotons and working fluid in a normal tank. The annihilation of antiprotons and normal matter takes place in the hollow region at the centre of the block. The γ-rays and charged pions from the matter - antimatter annihilation heat the tungsten block. The heat energises the working fluid passing around and through the block. A strong magnetic field surrounds the block forcing the annihilation products into spiral paths. They ionize the propellent and heat it even more



A solid core thermal rocket, based on a design by Bruno Augenstein, could be built using technology from the old American NERVA nuclear rocket programme. The photograph shows a NERVA rocket test setup, while the drawing shows rocket modified for antimatter propulsion.

Fig. 2

quickly turning it into a plasma exhaust. This would stream out at the back of the rocket and the rocket would accelerate in the opposite direction. An Augustein in rocket propulsion system would not be very large (fig. 2). Designs for an early version show the tungsten block in less than 30 cm long and weighing about 330 kg. More powerful version would be larger but still quite small compared with rocket propulsion systems now.

Another type of antimatter rocket was designed by David Morgan of the Laurence Livermore National laboratory in California. In one design magnetic fields of flux density 5.0×10^9 T control and contain the pions produced by annihilation. The pions are quided out through the thurst nozzle using magnetic field of flux density 2.5×10^8T. They acquire an exhaust velocity of 94% of the speed of light. The antiprotons would have to be injected into a tiny area of the precise centre of the thrust chamber. Morgan showed that this would not require an insuperable advance in present technology fig. 3

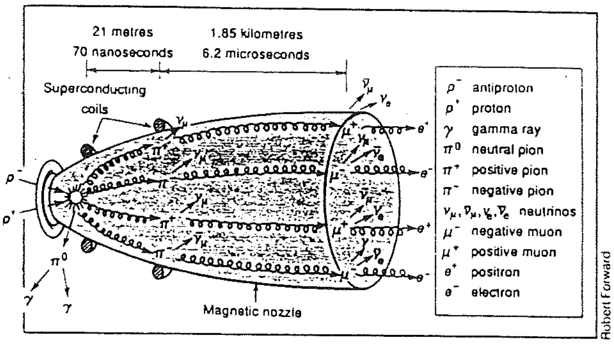


Fig. 3

An advanced antimatter rocket engine. Protons and antiprotons enter the engine at the left, annihilate and create gamma rays and pions. Superconducting magnetic coils direct the debris out of the thurst chamber as exhaust, generating thrust. The pions eventually decay to gamma-rays but by then they have travelled nearly two kilometres away from the rocket and its crew.

If now the efficiency of converting the antihydrogen energy to thrust energy were 30 percent, 12 milligrams of antihydrogen and 3.9 tonnes of propellent could accelerate a 1 tonne spaceship to 30 kms^{-1}. With additional milligrams of anti matter even greater velocities are easily attainable, without an increase in the mass ratio of the spaceship. For example an antimatter powered spaceship travelling from Earth to the planet Pluto at a constant acceleration of 1g (i.e. 9.8 ms^{-2}) would get there in less than three weeks!!

The prospectives are exciting. The development of an antimatter space propulsion system, even a first generation system like the Angenstein engine will make the Moon as accessible to Earth as Sidney is to London. More advanced propulsion systems will bring Mars and the innermost planets with a fortnight trip. Even distant Neptune and its interesting Satellite Triton will be only weeks away from anywhere in the solar system.

Much farther now from home in the darkness of the outer space one would imagine interstellar probes powered by antimatter. Such spaceships would require of course kilograms of antimatter instead of milligrams. Creating and storing such huge ammounts of antimatter is not an easy technological task and even the Earth would not be the suitable place for constructing such a factory.

Fortunately there is one place in the Solar system which is constantly flooded with enormous amounts of antimatter. The planet Mercury at a distance of 57.9 million kilometers from the Sun is continuously bombarded with antiparticles contained in the Solar flux and a factory of antimatter located in the Mercury's polar regions could take advantage of this continuous flux. The production of kilograms of antimatter per year could no longer be out of the question and the availabiltiy of kilograms of antimatter safely stored in advanced magnetic bottles using room temperature superconductors would move antimatter from the realm of exotic research to a mature technology in the years to come.

Other uses for antimatter:

Antimatter already has at least one down to Earth use, as a diagnostic tool. A medical technique called positron emission tomography (P.E.T.) can image tissues in the body. But more ambitious uses of antimatter be just around the corner. Undersea transportation is for example one possible use for antimatter power plants. Nuclear powered submarines might become relics of the past replaced by antimatter powered submersibles. An antimatter propulsion system would weigh less than either a conventional or nuclear power system take up less room and provide the submersible with enormous amounts of power. The working fluid for the power plant (ie water) could also be rather plentiful.

Augestein antimatter power plants could also supply electrical power for future undersea settlements. The power plant would be located in its reinforced dome some distance from the main village. Room temperature superconducting cables on the Ocean floor would carry electricity to the settlement. The undersea antimatter power plants might be very expensive to build but that expense could be justified for this kind of special location.

Antimatter therefore may not only open the Solar System to colonisation but also the world's ocean bottom.

REFERENCES:

1. *Mirror Matter: Pioneering antimatter Physics. R.L. Forward and J Davis. New York Wiley 1988.*
2. *Physicists make the most of antimatter (New Scientist Sept 1987).*
3. *The quantum Universe Hey and Walters. Cambridge*
4. *From quarks to quasars. P. Cadogan. Cambridge.*

MRP-JIT methodologies

A. Stassis, BSc (Hons) Prod. Eng.
Ph.D, Lecturer HTI

INTRODUCTION

It is proven that, by applying the right production methodology, companies can have up to 90 per cent of the benefits of fully automated systems like FMS at a fraction of the cost. Studies have shown that companies try to save 10 per cent on overmanning when they could save up to 50 per cent of the costs in tied up materials and work in progress. Parts that have taken minutes to produce spend weeks working their way through the production process travelling miles along the shopfloor.

Automation and Advanced Manufacturing Technology is a must if you want to survive but what is the use of investing huge sums of money before you even put your house in order.

Recently, two methods of production control seem to dominate the factory management, Material Requirement Planning (MRP) and Just in Time manufacturing (JIT). Many Industrialists argue about which is the best method and many suggest that using them both together as a tool for production control results in maximum benefit.

MRP

MRP is a planning system concerned with the sheduling of activities and the management of inventories. MRP is a "push" system because it forecasts a plan for meeting certain demands. This plan then drives the production through the issue of work orders.

In general terms MRP is a computerised database of parts, components, finished goods, work in progress and product requirements . Lead times and relationships between parts are also included. The final outcome is a Master Production Schedule based on forecasts, orders, stocks etc..

The requirements are calculated in terms of quantity and time. These requirements are then "exploded" in the Bill of Materials (BOM) files. BOM brakes down a product into its constituent parts. The requirements are then calculated after the deduction of any already available finished stocks. A schedule is finally calculated with the available flexibility to change the batch sizes. After that the system issues work orders to the relevant work centres. Any changes in the schedule are fed back into the system to ensure that the next plan is accurate.

MRP programs can be directly linked into accounting and other systems. This means that an MRP environment is heavily computerised requiring systematic and accurate updating of data. It is best suited to factories with many different types of products.

JIT

Just in time manufacturing is a "pulling" type of production and is based on simplicity. Its goal is to produce and deliver at the right time the required quantity and quality of goods. Nothing is produced, however, unti just before it is needed.

The Japanese were the first to actually use JIT successfully especially in their motor and electronic industries. The philosophy behind JIT in simple terms is that you produce only if there is an empty tray. If the tray is full, stop production.

JIT is risky because inventories are kept to a minimum and planning is short term. Very high objectives are set for the production managers such as zero defects, zero set up times, zero handling time, zero breakdowns, zero lead times and a batch size of one. Every production manager knows that for this to be achieved it is almost impossible. Attempting to achieve these objectives however is what has made JIT so famous. In trying to meet those highly demanding objectives the production manager is organising the actual production to perfection.

Faulty goods are eliminated by total quality control techniques, break downs are avoided by adopting preventative maintenance etc..

The productivity of labour increases because JIT easily identifies a non productive person or centre. JIT systems enable production of high quality products at very short notice. Manufacturers usually start implementing JIT department by department after first making sure that a high level of management control exists. Production or Industrial Engineers are best suited for this task. JIT involves cultural changes at every level within the factory and amongst suppliers and customers. Suppliers and buyers are a part of the manufacturing chain and they have to accept the philosophy. Suppliers have to provide high quality goods at shorter notice and customers have to be willing to accept smaller quantities of goods with greater quality and product range at more frequent intervals. For most customers this is more desirable anyway.

For countries like Cyprus which buy raw materials from abroad with a month or two delivery time, JIT can be implemented ignoring the stock of raw materials, which should however be kept as far as possible to a minimum.

JIT requires perfectly balanced production lines and workers with multiple skills, ready to leave from one line or group and work on another. One fault will hold up the whole line. Group Technology can ensure smooth production with maximum flexibility. Standardization of parts and tools will surely make life easier, and correct organisation should ensure that the systems are able to change quickly from making one model to another. Japanese factories managed to drop the changing and setting time of a press die to less than a minute.

Although JIT can work succesfully without any sort of computerisation great improvements can be achieved by including computing and Advanced Manufacturing Technology. Here is where MRP could work side by side with JIT. The running of MRP will have to take place daily. Computerised machine tools may be closely monitored and quickly switch from machining one model to another transmitting the stored programs directly (DNC).

JIT can be used by large companies as well as small companies. It all depends on a very high degree of organisation. If you are thinking to introduce JIT start by reducing the inventory and give your self plenty of time. Don't forget that going towards the JIT goals is enough to start getting the benefits.

Selection of mode tracking for line focus concentrating collectors

Soteris Kalogirou
Laboratory Assistant, HTI

Solar line focus concentrating collectors with concentration ratios greater than 10 employ some form of tracking mechanism in order to follow the sun. This is done in varying degrees of accuracy and modes of tracking.

Tracking systems can be classified by the mode of their motion. This can be about a single axis or about two axes. In the case of a single axis mode the motion can be in various ways i.e. east-west, north-south or parallel to the earth's axis.

The objective of this article is to investigate the solar incidence angle variation and the amount of solar energy received by the collector for five different modes of tracking. Finally the best tracking mode will be selected. The selection criteria used are, cost, variation of solar incidence angle and maximum energy collection. The analysis is done for the geographic location of the town of Nicosia-Cyprus.

1. THE SOLAR INCIDENCE ANGLE, Θ

The solar incidence angle, Θ is the angle between the sun's rays and the normal on a surface [1,2]. The Solar incidence angle is related to the other basic solar angles in the following general expression [1,2,3]:

$$\cos(\Theta)= \sin(L)*\sin(\delta)*\cos(\beta)- \cos(L)*\sin(\delta)*\sin(\beta)*\cos(Zs)+\cos(L)*\cos(\delta)*\cos(h)*\cos(\beta)+ +\sin(L)*\cos(\delta)*\cos(h)*\cos(\beta)*\cos(Zs) +\cos(\delta)*\sin(h)*\sin(\beta)*\sin(Zs) \quad (1)$$

where

L = Latitude
δ = Solar declination angle
h = Hour angle
β = Surface tilt angle from the horizontal
Zs = Surface azimuth angle; angle between the normal to the surface from true south.

NOTE: A detailed explanation and formulation of all solar angles is given in 1989 HTI Review article pp 51-54 of the same author.

Equation (1) is a general relationship for the angle of incidence on a surface of any orientation. As can be seen later on, this reduces to much simpler forms for specific cases of orientation or tracking mode.

The optical efficiency of solar line focus concentrating collectors depends on three parameters, the specular reflectance fo the reflector, the transmittance of any cover system and the absorptance of solar radiation on the receiver. The second and third parameters are heavily dependent on the incidence angle. Therefore a careful study of the incidence angle is of utmost importance.

The following equations are derived from the general equation (1), and apply to planes moved as indicated in each case.

1.1 Full Tracking

For a two axis tracking mechanism keeping the surface in question continuously oriented to face the sun, will at all times have an angle of incidence Θ equal to:

$$\cos(\Theta) = 1 \quad (2)$$

or $\Theta=0^0$. This of course depends on the accuracy of the mechanism. The full tracking configuration collects the maximum possible sunshine.

1.2 N-S Axis / Tilt Daily Adjusted

For a plane moved about a North - South axis with a single daily adjustment so that is surface -normal coincides with the solar beam at noon each day, Θ is equal to [2,3]:

$$\cos(\Theta) = \sin^2(\delta) + \cos^2(\delta)*\cos(h) \quad (3)$$

This configuration is shown in Fig 1. We can accept that when the sun is at noon the angle of sun's rays and the normal to the collector can be up to 4^0. Figure 2 shows the number of consecutive days that the sun remains within this 4^0 "window" at noon. As can be seen in Fig 2 the sun remains most of the time close to either the summer solstice or the winter solstice moving rapidly between the two extremes. For nearly 70 consecutive days the sun is within 4^0 of an extreme position, spending only 9 days in the 4^0 window at the equinox. This means that a seasonally tilted collector need be adjusted only occasionally [2].

The problem encountered with this and all tilted collectors, when more than one collector is used, is that the front collectors cast shadows on adjacent ones. This means that in terms of land utilisation these collectors loose some of their benefits when the cost of land is taken into account.

1.3 N-S Axis Polar / E-W tracking

For a plane rotated about an east - west axis parallel to the earth's axis, with continous adjustment, Θ is equal to [1,2,3]:

$$\cos(\Theta) = \cos(\delta) \quad (4)$$

This configuration is shown in Fig 3. For this arrangement the sun is normal to the collector at equinoxes ($\delta=0^0$) and the cosine effect is maximum at the solstices. The same comments about tilting of the collector and shadowing effects apply here as in the previous configuration.

1.4 N-S Axis Horizontal / E-W Tracking

For a plane rotated about a horizontal east - west axis with continuous adjustment to minimise the angle of incidence, Θ can be obtained from [1,3]:

$\cos(\Theta) = [1-\cos^2(\delta)*\sin^2(h)]^{0.5}$ .... (5)

or from equation [2]:

$\cos(\Theta)=[\sin^2(\delta)+\cos^2(\delta)*\cos^2(h)]^{0.5}$ .... (6)

The basic geometry of this configuration is shown in Fig 4. The greatest advantage of this arrangement is that very small shadowing effects are encountered when more than one collector is used. These are present only during the first and last hours of the day.

1.5 E-W Axis Horizontal / N-S Tracking

For a plane rotated about a horizontal north - south axis with continuous adjustment to minimise the angle of incidence, Θ can be obtained from [1,3]:

$\cos(\Theta)=[\sin^2(\alpha)+\cos^2(\delta)*\sin^2(h)]^{0.5}$ .... (7)

or from equation [2]:

$\cos(\Theta)=\cos(\Phi)*\cos(h)+\cos(\delta)*\sin^2(h)$ ..... (8)

The basic geometry of this configuration is shown in Fig 5. The shadowing effects of this arrangement are minimal. The principal shadowing is caused when the collector is tipped to a maximum degree south ($\delta=23.5^0$) at winter solstice. In this case the sun casts a shadow toward the collector at the north.

All these tracking modes will be further analysed and compared later on, in order to decide, which one to apply for high efficiency and low cost.

1.6 Incidence Angle Analysis

The complexity of the various equations involved in the determination of the solar angles necessitates the use of computers in order to make a detailed investigation into the subject. A program written by the author is used in the analysis that follows.

In this section the incidence angle for four tracking modes will be analysed.

The angles will be analysed on a daily and annual basis. The analysis is carried out for the location of Nicosia-Cyprus. The analysis is done for four days, the two solstices and the two equinoxes.

The yearly variation of solar incidence angle for, five different hours, for a collector having its axis in a N-S directions with its tilt daily adjusted is shown in Fig 6. As it can be seen the variation throughout the year for the same hours is small in the order of $\pm 4.5^0$ although the variation throughout a day is quite large as it can be seen from Figs 10 to 13.

For the case of a collector having its axis in a N-S direction tilted at the polar axis (35^0 for Nicosia-Cyprus), employing E-W tracking, the yearly variation is shown in Fig 7 i.e. is the same as the variation of the solar declination angle throughout the year. The daily variation is shown in Figs 10 to 13 and is constant throughout the day.

The yearly variation of the incidence angle for a collector having its axis in a horizontal N-S direction and employing E-W tracking is shown in Fig 8 and is very similar to the collector with its tilt daily adjusted. These tracking mechanisms, also have the same daily behaviour as it can be seen from Figs 10 to 13. Thus, when shading effects are considered, for more than one collector installation, and the weighting factor governing the decision on the tracking mode is the variation of the incidence angle, the horizontal configuration must be used.

For the case of a collector having its axis in a horizontal E-W direction employing N-S tracking, the yearly variation is shown in Fig 9. This variation is large, the maximum value is 47^0. The daily variation is shown in Figs 10 to 13. It can be seen from these graphs that the variation is not that great (of the order of 12^0).

For a two axis tracking mechanism the incidence angle is zero degrees. This off course depends on the accuracy of the mechanism and its control system.

2. SOLAR RADIATION COLLECTION

The earth is surrounded by an atmosphere which contains various gaseous constituents, suspended dust and other minute solid and liquid particulate matter and clouds of various types. Therefore, the solar radiation is depleted during its passage through the atmosphere before reaching the earth's surface. The reduction of intensity with increasing zenith angle of the sun is generally assumed to be directly proportional to the increase in air mass, an assumption that considers the atmosphere to be unstratified with regard to absorbing or scattering impurities [2]. The variation of the solar flux at ground level is given by the following empirical equation [2].

$I_{(\Phi)} = Io\ Exp\ [-c\ (\sec(\Phi))^s]$ .... (9)

where c = constant = 0.357

s = constant = 0.678

If the surface is question is at an elevation H, Eq (9) is modified as [2]:

$I_{(\Phi)} = Io\ (1-AH)\ Exp\ [-c(\sec(\Phi))^s] + AHIo$ .... (10)

where H = the site elevation [Km]

A = 0.14 per kilometer altitude

The general equation for calculating the direct solar energy incident on an inclined surface is [2,3]:

$I=I_{(\Phi)}*\cos(\Theta)$ .... (11)

2.1 Solar Radiation on Moving Surfaces

The thermal performance of a Line Focus Collector (LFC) depends mainly on the amount of solar radiation incident on it's aperture area. This depends on the mode of tracking mechanism used. For the analysis of solar radiation received by a moving surface equations (10) and (11) will be used. In Eq (11) for the term cos(Θ) the equations given in section 1 will be used. The angles Φ, β and h are time dependent for concentrating systems because the orientation of the receiving surface varies with time. By integrating Eq (11) in time intervals t1 and t2 (from sunrise to sunset) the amount of energy that reaches the collector during one day for standard conditions can be found. Therefore, the best tracking mechanism will be the one which collects the higher amount of energy.

A full tracking mechanism moves with two degrees of freedom and follows the sun continuously. This assembly collects the maximum amount of beam radiation. The performance of this assembly at the equinoxes and at the summer and winter solstices is shown in Fig 14.

The performance of a collector having its axis in a N-S direction with its tilt daily adjusted is shown in Fig 15.

The performance curves of a collector having its axis in a N-S direction tilted at the polar axis employing an E-W tracking are shown in Fig 16. The equinox and summer noon performance are essentially equal, the smaller air mass for summer solstice offsetting the small cosine projection effect. The winter noon value, on the other hand, is reduced because these two effects combine rather than cancel. If it is desired to equalise the summer and winter curves, an inclination higher than the polar mount would suffice; but the physical height of such configuration would be a potential penalty to be treated off in cost efectiveness with the structure of the polar mount. Another side effect is that of shadowing of the adjacent collectors, for multi-row installations for increased inclination.

The performance curves for a collector having its axis in a horizontal N-S direction and employing E-W tracking are shown in Fig 17. This assembly has an advantage in that it approximates the full tracking collector in the summer, but the cosine effect in the winter greatly reduces its effectiveness. The curves in Fig 17 show that this mount yields a rather "square" profile, ideal for leveling the variation during the day. The winter curve, however, is seriously depressed relative to the summer curve indicating a rather poor winter performance.

The performance curves for a collector having its axis in a horizontal E-W direction employing N-S tracking are shown in Fig 18. In this case the curves are closer to a cosine curve function. The daily variation at winter solstice is small and such a collector gives well balanced seasonal performance.

The choice of the tracking mechanism will be dealt with in the next section where all the modes will be compared, not only with respect to the incidence angle variation and the amount of solar energy collected but also with respect to the tracking mechanism and control system cost.

3. SELECTION OF TRACKING MODE

The criteria to be used in the selection of tracking mode are, the variation of incidence angle, energy collection and cost. The fact is that a full tracking collector is the best considering the first two parameters but it is the worst with respect to cost. This is because twice as many equipment are required to move the collector in two directions. Therefore with respect to cost the full tracking collector is abandoned and the tracking mode that best approaches the full tracking one, with respect to the variation of incidence angle and solar energy collected will be chosen.

3.1 Incidence Angle Variation

For one axis tracking mode the incidence angle have the effect of image enlargement on the focus point of the parabola. The beam radiation incident on the aperture of the collector will be parallel to the central plane of the reflector but at an angle of incidence on the aperture as described in section 1 by equations (2) to (8). A theoretical image from any point on the reflector will be enlarged by a factor $1/\cos(\Theta$[3]. Since $1/\cos(\Theta)$ is reduced as the angle Θ is reduced the best tracking mode in this respect is the one that has the smaller incidence angle and the smallest vatiation of the incidence angle throughout a day and a year. From Figs (6) up to (13) it can be seen that the collector which employs an E-W tracking with its axis inclined at the polar axis (35^0 for Nicosia Cyprus) has the smaller angle and the smaller variation. The only case where another mode of tracking would be better is at Summer solstice, Fig 11, where the N-S Horizontal mode has a smaller incidence angle throughout the day as compared to the E-W polar one. But the incidence angle variation of the N-S Horizontal mode is higher in all other seasons and it is worst at winter solstice.

3.2. Solar Energy Collected

Figures (19) to (21) were constructed by using the data shown in Figs (14) to (18) for each mode of tracking for the equinoxes and the summer and winter solstices. Therefore the daily variation of solar flux will be compared by drawing on the same graph the curves for the five different tracking modes for the equinoxes and the summer and winter solstices. The comparison will be made with respect to the full tracking which collects the maximum amount of solar radiation but was dropped because of its cost.

In the case of equinoxes, Fig 19 the curves of the full tracking and that of E-W Polar mode are exactly the same. This is because the declination angle is zero degrees at equinoxes. In winter solstice, Fig 20, the second best is the E-W polar mounting. In summer solstice, Fig 21, the second best close to the full tracking is the N-S Horizontal mode with the E-W Polar coming third.

A second comparison is done with respect to solar energy collected by considering the area under each curve. This area is a measure of the solar energy collected throughout the day in

Kwh/m². These data will again be compared to the full tracking mode, Fig 22, where a 100% energy collection is shown. The E-W polar mode of tracking is 100% efficient at equinoxes, but comes second in winter solstice with 91.7% and third at summer solstice with again 91.7%. Therefore at worst conditions (at the solstices) almost 92% of the available beam solar radiation will be collected.

3.3. Conclusion

From the above discussion it can be concluded that the tracking mode to be selected is the E-W polar mounting. The only problem with this mounting is the shading effects which are present in multi - row installations. In such cases the best tracking mode according to the above discussion is the N-S Horizontal.

REFERENCES

1. *Frank Kreith and Jan F. Kreider, Principles of Solar Engineering, McGraw-Hill Book Company, 1978.*
2. *Aden B. Meinel and Marjorie P. Meinel, Applied Solar Energy, An Introduction, Addison-Wesley Publishing Company 1976.*
3. *John A. Duffie & William A. Beckman, Solar Engineering of Thermal Processes, A. Wiley - Interscience publication, 1980.*

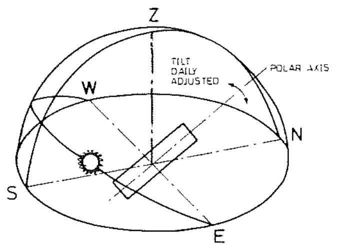
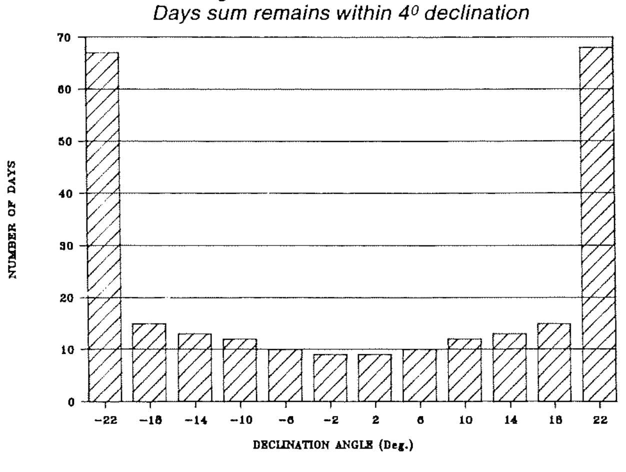


Fig. 1 N-S Axis Tilt Daily Adjusted

Fig. 2 Number of consecutive Days sum remains within 4⁰ declination



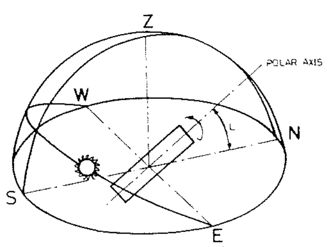


Fig. 3 N-S Axis Polar E-W Tracking

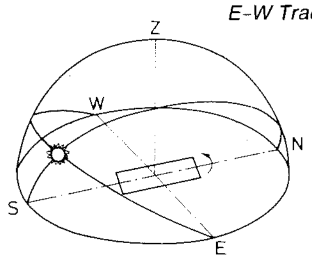


Fig. 4 B-S Axis Horizontal E-W Tracking

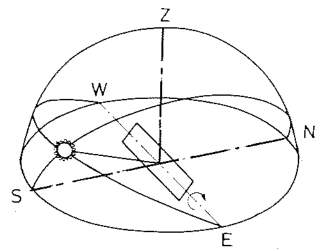


Fig. 5 E-W Axis Horizontal N-S Tracking

Fig. 6 Incidence angle variation

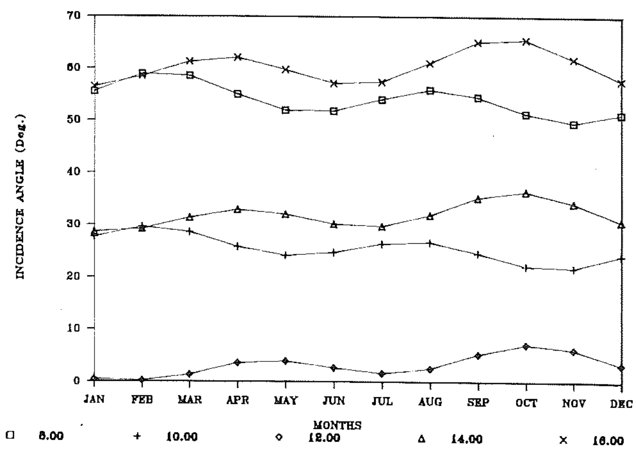


Fig. 7 Declination angle on the sun Tilt Daily Adjusted

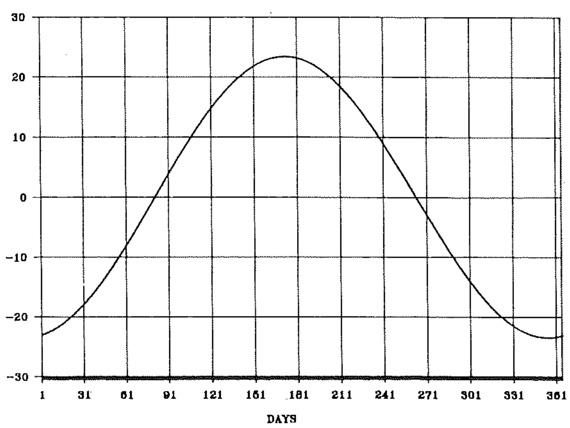


Fig. 8 Incidence angle variation
E-W Tracking / Horizontal

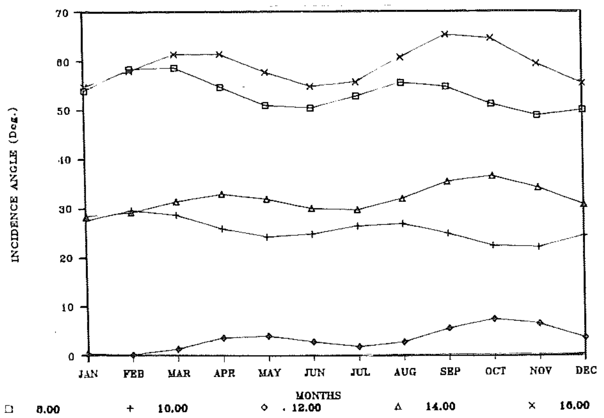


Fig. 9 Incidence angle variation
N-S Tracking / Horizontal

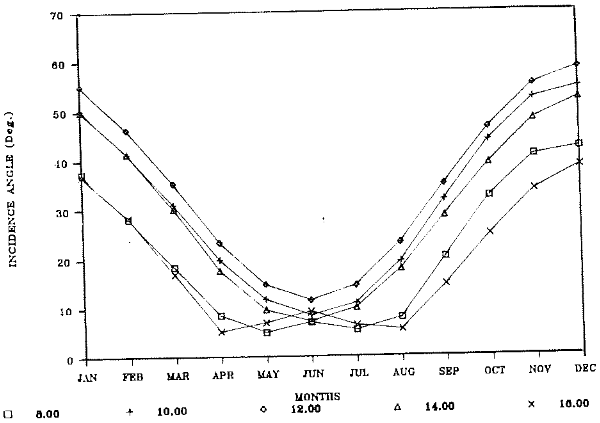


Fig. 10 Incidence angle variation
March 21

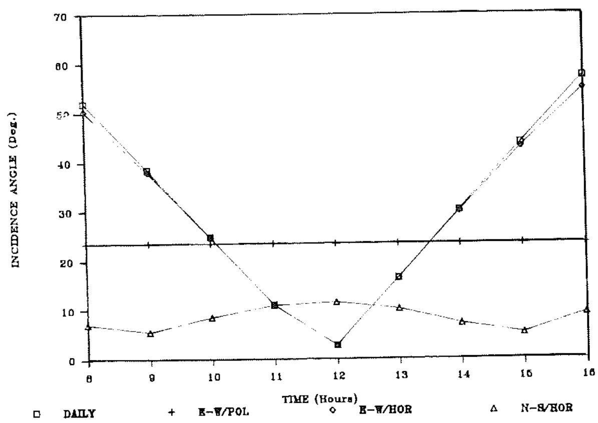


Fig. 11 Incidence angle variation
June 21

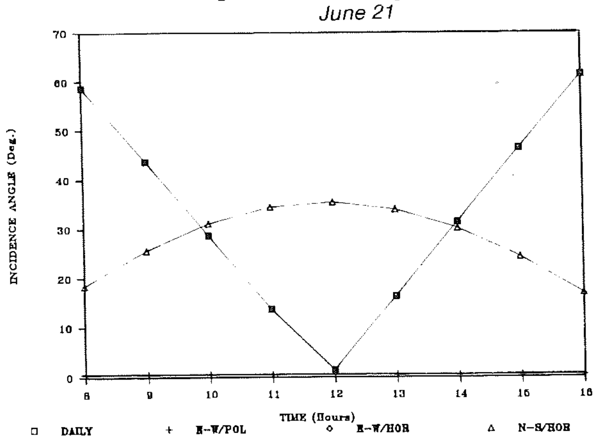


Fig. 12 Incidence angle variation
September 21

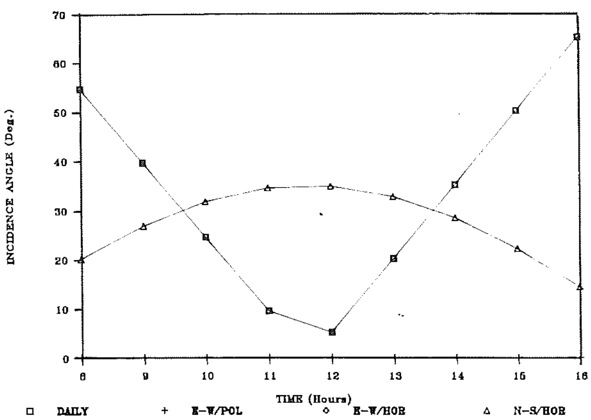


Fig. 13 Incidence angle variation
December 21

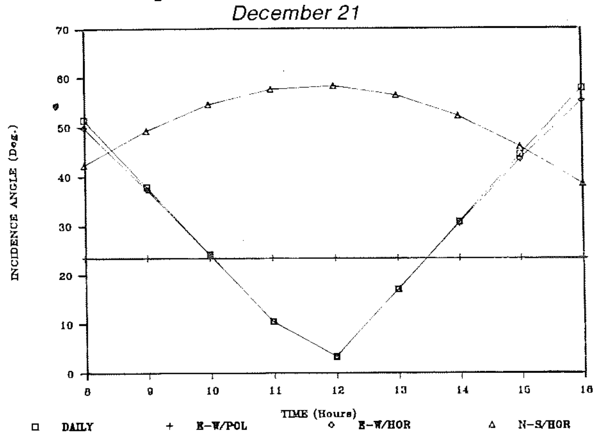


Fig. 14 Full Tracking
Daily variation of solar flux

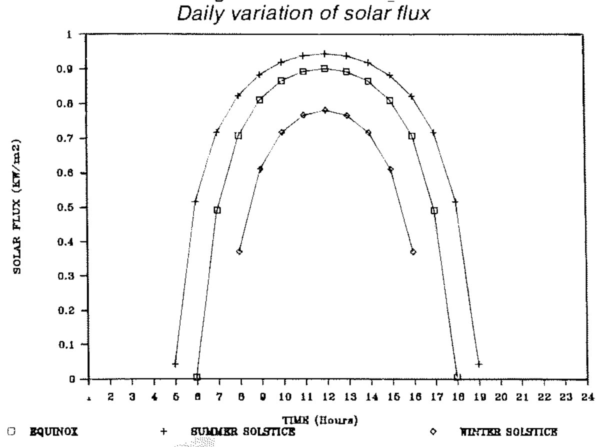


Fig. 15 N-S Axis/tilt daily adjusted
Daily variation of solar flux

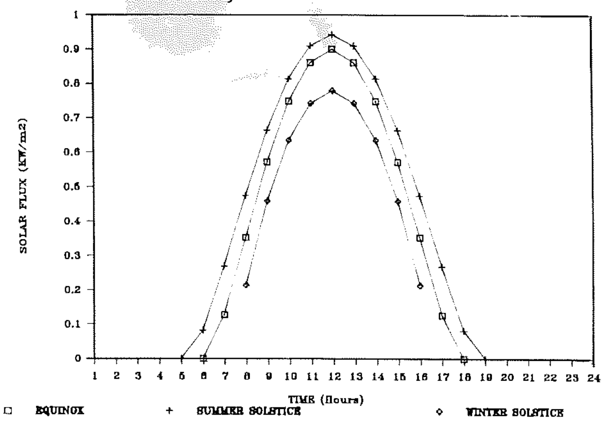


Fig. 16 N-S axis polar/E-W tracking

Daily variation of solar flux

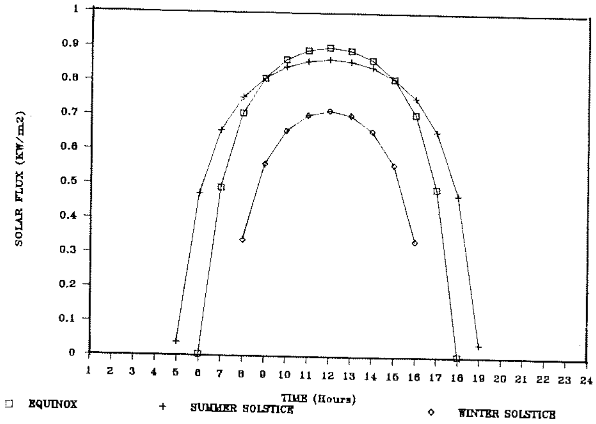


Fig 19 Winter solstice

Daily variation of solar flux

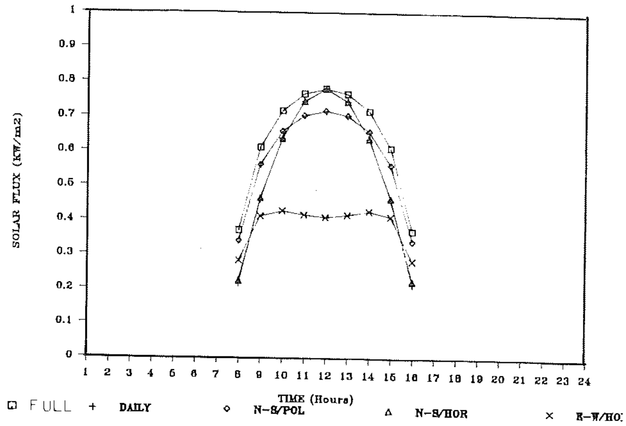


Fig. 17 E-W axis horiz./N-S tracking

Daily variation of solar flux

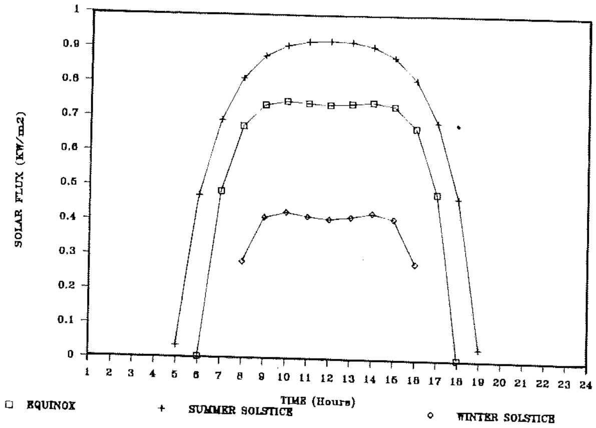


Fig. 20 Equinoxes

Daily variation of solar flux

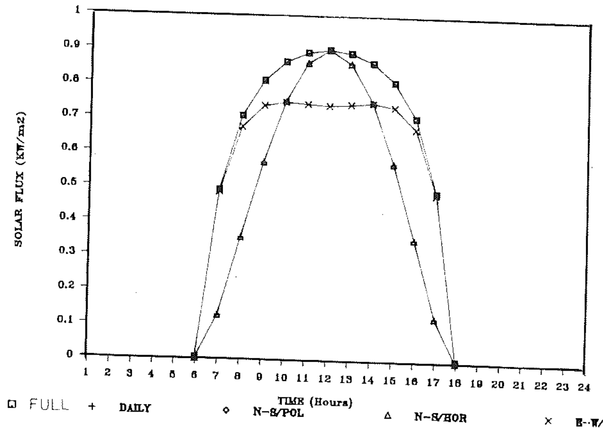


Fig 18 N-S axis horiz./E-W tracking

Daily variation of solar flux

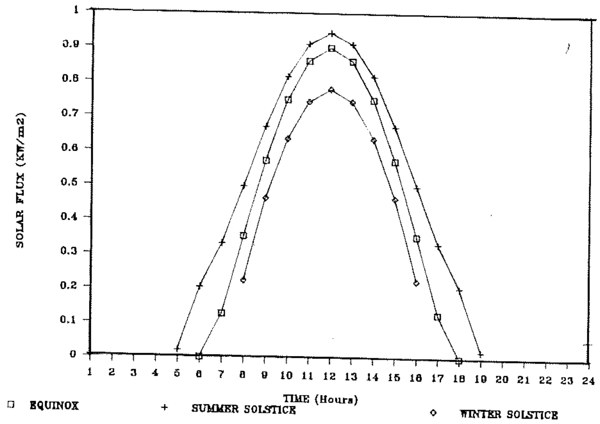
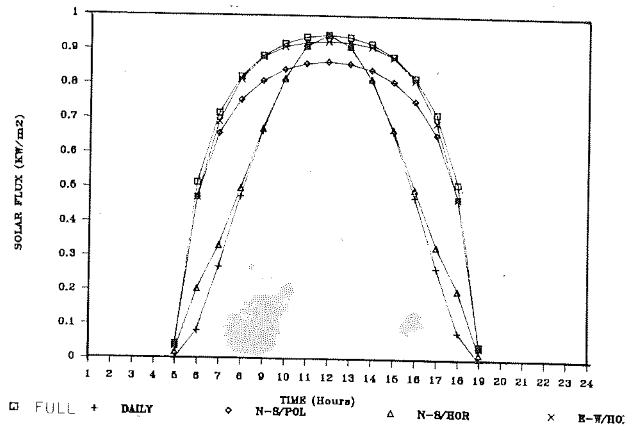


Fig. 21 Summer solstice

Daily variation of solar flux



TRACKING MODE	SOLAR ENERGY (KWh/m2)			PERCENT TO FULL TRACKING		
	EQUINOXES	SUMMER SOLSTICE	WINTER SOLSTICE	EQUINOXES	SUMMER SOLSTICE	WINTER SOLSTICE
FULL TRACKING	8.428	10.603	5.696	100.0	100.0	100.0
DAILY ADJUSTED	6.222	7.373	4.880	73.8	69.5	85.7
E-W POLAR	8.428	9.727	5.226	100.0	91.7	91.7
N-S HORIZONTAL	6.222	7.846	4.912	73.8	74.0	86.2
E-W HORIZONTAL	7.508	10.364	3.471	89.1	97.7	60.9

Fig. 22 COMPARISON OF ENERGY ABSORBED FOR VARIOUS TRACKING MODES

Sail technology - the future

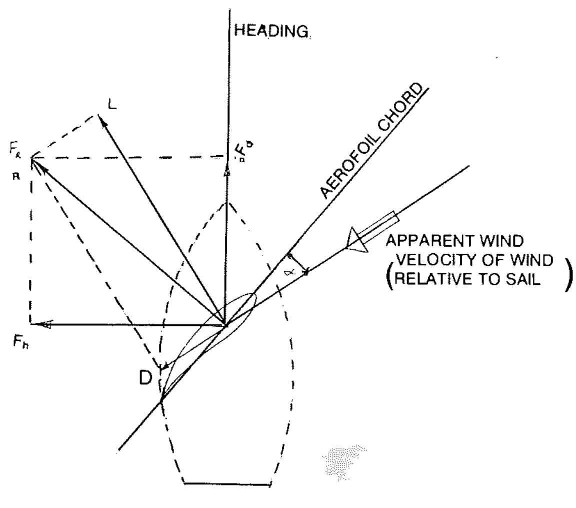
Petros Kronis BSc(Eng) (Lon) (Hons)
Mechanical Engineer,
Member, Kyrenia Nautical Club

In this article the future of sail technology is reviewed and possible new sail designs are discussed at a generalised level. Some consideration is also given to the detailed engineering design of various concepts.

In contrast to the aeroplane wing, which began its development as a single sheet of fabric and developed in a matter of a few years to a rigid aerofoil construction, the concept of the fabric sail has changed little since ancient times. Even in the technological age of today the sail seems to be in a dominant position and well poised to sail into the 21st century. However there have been moves recently to "rock the boat" and the development of the automated rigid sail system seems a good contender for the "race of the sails".

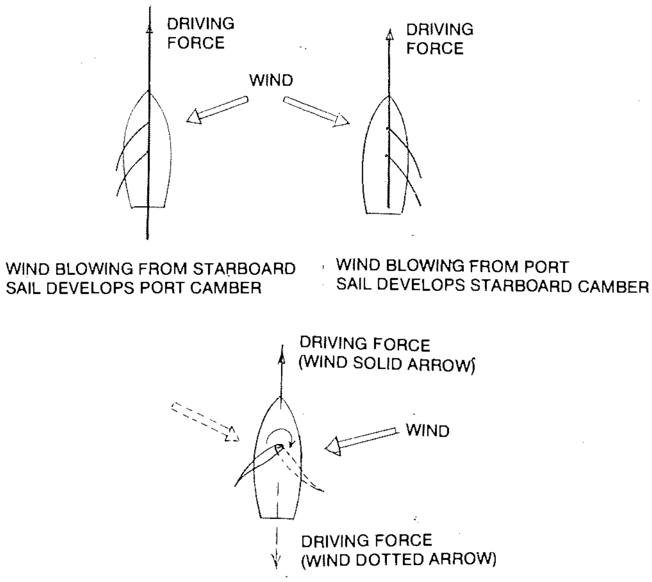
SAIL AERODYNAMICS

Fig. 1 shows the aerodynamic and geometrical terms used in the theory of the sail. Lift (L) and Drag (D) are the aerodynamic forces produced by the sail which are resolved into the Driving (Fd) and Heeling (Fh) forces which make the boat move on the water. The component of the force which produces forward motion is of course Fd. The Heeling force (Fh) produces no useful work but tends to overturn the boat and also produces sideways drift, the magnitute of which depends on the shape of the hull below the water line. One of the effects of the Heeling force is that it makes the boat follow a course which is different to its heading.



α = Angle of incidence
L & D = Aerodynamic Lift and Drag forces
F_R = Resultant force
F_d = Driving force component
F_h = Heeling force component

Fig. 1



VARIABLE GEOMETRY CANNOT BE ACHIEVED BY SIMPLY ROTATING THE RIGID SAIL ABOUT ITS AXIS

Fig. 2

Fig. 2 shows that flexibility is one of the strong merits of the fabric sail. When the wind changes direction so does the geometry of the sail. A rigid sail with "variable geometry" demands more advanced technology than that developed for the aeroplane wing. The rigid sail has to operate at the maximum possible efficiency when producing positive force (port force), as well as when producing negative force (starboard force). In contrast, the aeroplane wing needs to be efficient only when producing positive lift. Spoilers are used to destroy lift when it is not required, and gravity is utilised to bring the aeroplane down.

Theoretically, the force coefficients (lift and drag coefficients) produced by rigid aerofoils compare favourably with those produced by fabric sails. Fig. 3 shows typical Lift/Drag curves for the Bermudan sail rig, with superimposed curves for the Wortmann aerofoil section. Some aerofoil sections have been developed specially for low airspeeds and may be applicable for sail use. Examples are the aerofoil sections developed for man-powered flight. Fig. 4 shows the Wortmann section which was developed for this purpose by aerodynamicists at British Aerospace. The shape of these sections renders them difficult to use with variable geometry. High aerodynamic efficiency may have to be traded for the benefits of variable geometry. In Fig. 4(a) a variable geometry aerofoil is shown using a simple pivoting trailing edge flap. Other relevant aerofoil concepts are those with one or more slots (slotted aerofoils). If a new aerofoil section is designed then its performance characteristics must be established experimentally in a wind tunnel before it can be incorporated into the sail system.

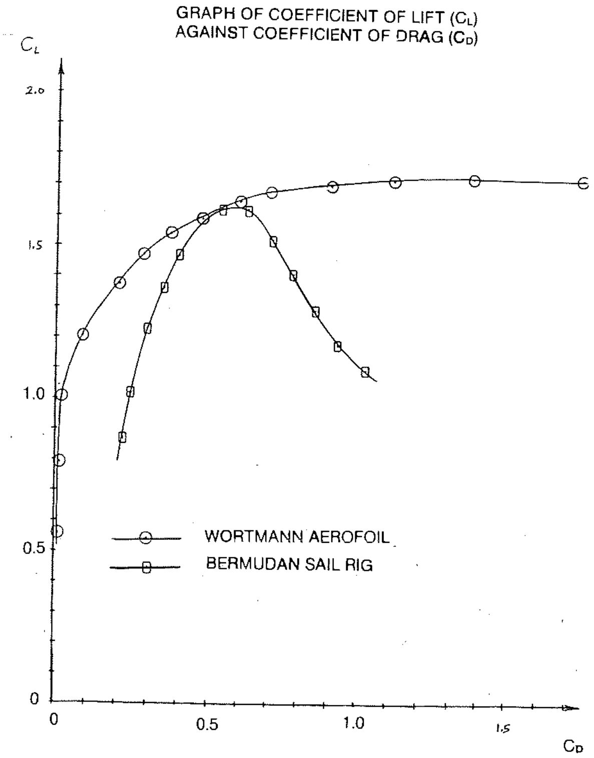


Fig. 3

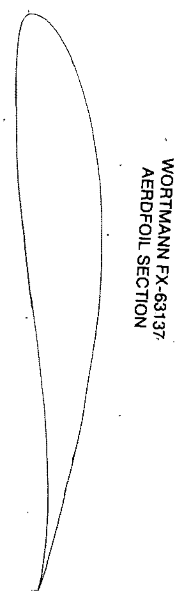


Fig. 4

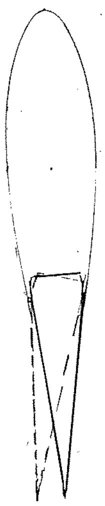


Fig. 4(a)

Rigid Sail Mechanics

The mechanics of the rigid sail system probably poses the greatest technical challenge for the designers. Apart from the fact that the system has to employ variable geometry, it also has to be made retractable. Fig. 5 shows various possible concepts.

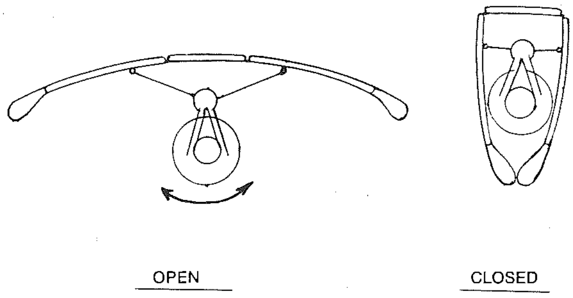


Fig. 5(a)

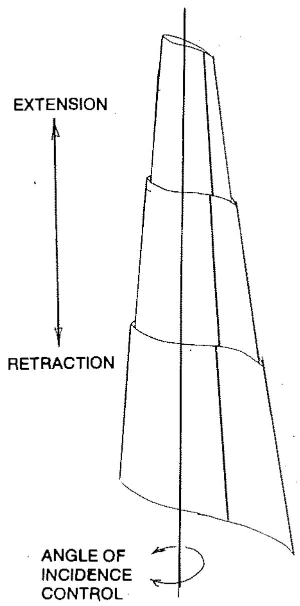
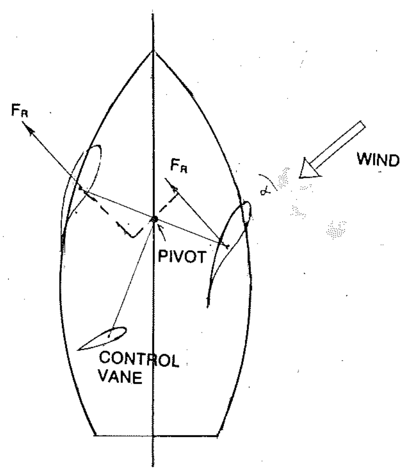
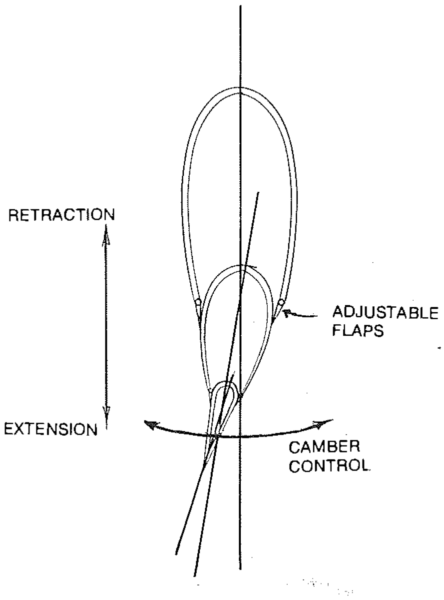


Fig. 5(b)



FREE FLYING RIGID SAIL SYSTEM

Fig. 5(c)



NESTED AEROFOIL SYSTEM

Fig. 5(d)

In Fig. 5 (a) the sail is made symmetrical about the longitutinal axis of the ship, therefore dispensing with the need to employ variable geometry. The sail retracts by folding around a central mast to reduce profile drag when it is not in operation. The operation of this system involves two actions, retraction/extension and rotation to set the correct angle of incidence for maximum driving force. It should be noted that this type of sail has been used on large ships as an auxilliary source of power to help reduce fuel consumption. For this reason high efficiency is not of primary importance.

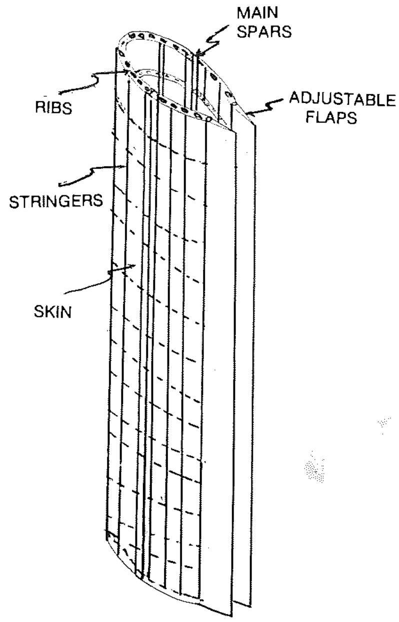
In Fig. 5(b) the sail extends and retracts vertically, and rotates about its axis for angle of incidence control. This system poses many technical difficulties and has the disadvantage that a large part of the cabin of the vessel will be taken up by the system structure and mechanics.

The free flying rigid sail shown in Fig. 5(c) has the advantage of simple mechanics and good structural integrity. In this system the rotation of the sail is controlled by a vertical tail vane (rudder). In this way the operation of the system is achieved aerodynamically rather than mechanically, therefore reducing the mechanical complexity. This particular system does not retract but is "feathered" when not in operation, rather like the blades of an aircraft propeller after an engine is switched off in flight. In this position the sail produces the minimum drag.

Fig. 5(d) shows a suggestion for a retractable variable geometry sail system. Its main advantage is the high aerodynamic efficiency that can be achieved if well designed, and a mechanical system which can combine the operations of extension/retraction with that of Variable Geometry. This "nested" aerofoil system could be used as part of a free flying (aerodynamically controlled) or mechanically controlled incidence system.

Structural Design

Structurally each of the systems described above presents unique problems for the designers. Generally a high mechanical complexity also means greater structural complexity. The rigid aerofoil system is structurally straightforward in design. However in some of the designs presented above, as is the case of the nested system, the open C-shaped section presents some structural weaknesses especially in torsion. In Fig. 6 the main structural elements of a rigid sail are shown.



RIGID SAIL STRUCTURAL ELEMENTS

Fig. 6

The materials to be used for the construction of rigid sails must be light and strong. Aluminium alloys similar to those used in the aircraft industry will be applicable.

AUTOMATIC CONTROL

A rigid sail system will not be worth employing if it is difficult to control. The multitute of parameters to be considered forces the designer to opt for computerised control. To facilitate the design of the computer software system, a logic diagram or flowchart can be drawn. Fig. 7 shows such a flowchart in a block diagram form.

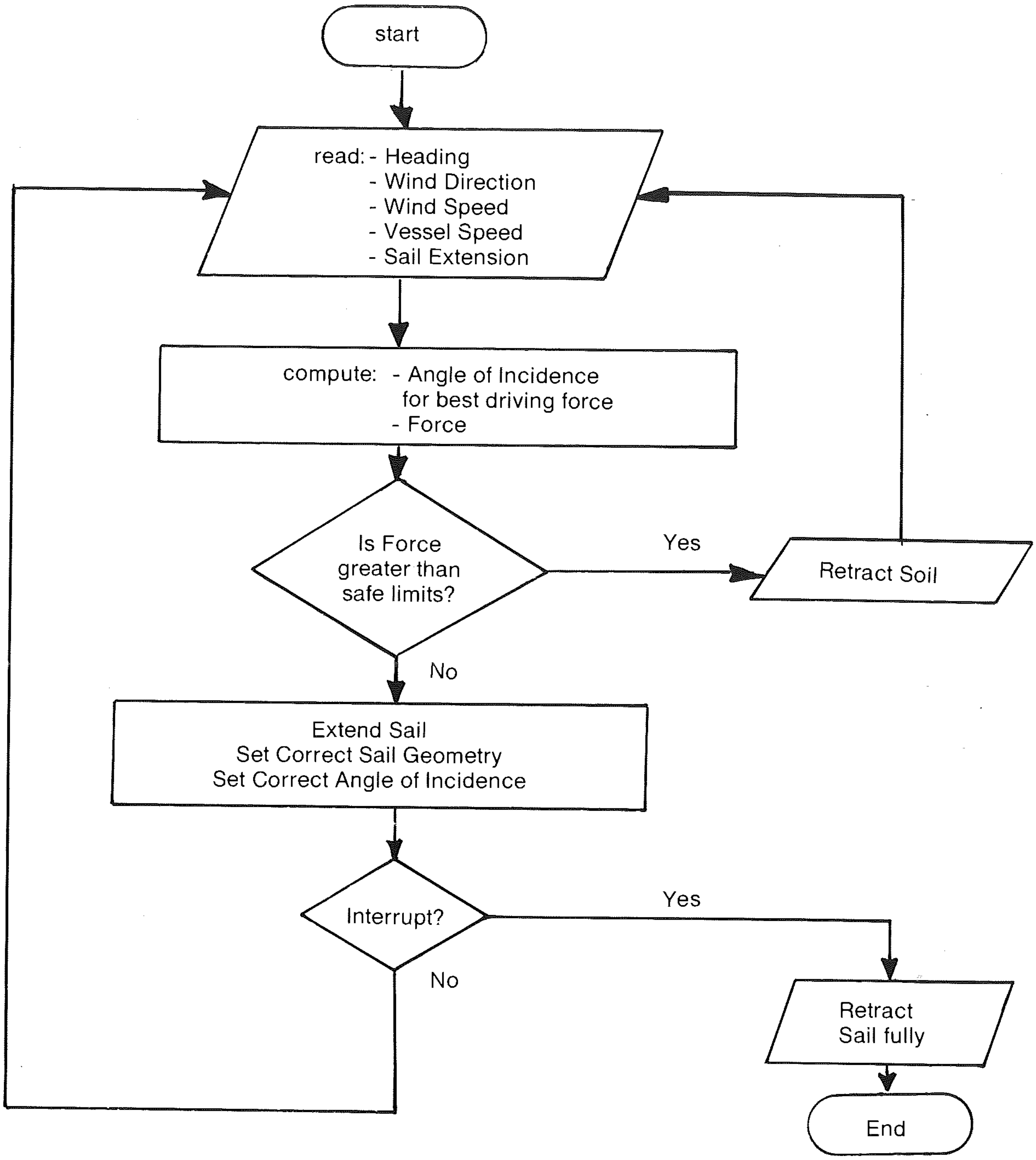


Fig. 7

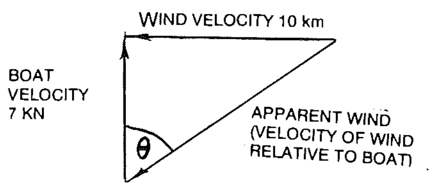
Automatic helm control is not shown in the above flowchart for simplicity, but it will have to be incorporated as part of an integrated control system.

Most of the blocks in the flowchart will have to be analysed further in more detail, as illustrated below for the computation of the angle of incidence, and the forces produced by the sail.

INPUT DATA:	*Heading*	*= 0 degrees*
	Boat speed	*= 7 knots*
	Wind speed	*= 10 knots*
	Wind direction	*= 90 degrees*

Step. 1 (Compute apparent wind velocity).

From velocity triangle obtain the apparent wind velocity (velocity of wind relative to boat or sail).

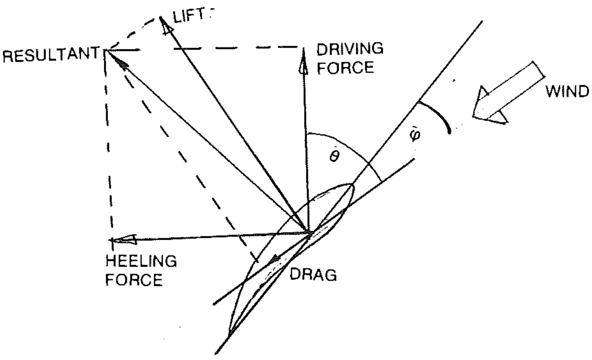


In practice the apparent wind velocity will be read directly from the on-board anemometer.

Step 2. (compute the angle of incidence)

The aerofoil will have to be positioned at an angle (θ - φ) at which the sail will produce the maximum driving force with the minimum heeling force.

To obtain the angle of incidence φ, the on-board computer will have to refer to the performance characteristics of the aerofoil section and perform calculations to maximise the driving force. Having calculated the angle φ and established the coefficients of Lift and Drag, the Driving and Heeling forces can be calculated. Using these values the computer will be able to give instructions for the correct setup of the aerofoil geometry, extension, and sail attitute. Unfortunately the calculations will not be the same for all the sailing modes. For example, when the boat is sailing on a run, it will be better to turn the sail so that the planform area is at right angles to the wind, and to utilise the Drag as the driving force instead of the Lift. It may be advantageous to analyse all the possible sailing conditions at the design stage and provide the on-board computer with a look-up table for reference. In this way the computing load on the on-board computer will be reduced, allowing it to be made smaller and cheaper.



The purpose of the present article is not to give ready made solutions to the exciting and challenging engineering problem of the rigid sail. On the contrary the discussion has been limited to the concept design phase of the Design process. The interested engineer may wish to study additional design solutions before embarking on further development and testing.

The theme of industrialization in the poetry of D.H. Lawrence

Dena Charalambidou-Solomi,
D.E.S., B.A. (Hons), M.A.
Lecturer, H.T.I.

D.H. Lawrence (1885-1930) is well known for his controversial novels and short stories. His televised novels SONS AND LOVERS, WOMEN IN LOVE, RAINBOW and LADY CHATTERLEY'S LOVER have made D.H. Lawrence a household word.

His poetry, however, is not widely known and it has not been highly acclaimed by the critics.

The objective of this article is to examine the use of the theme of industrialization in Lawrence's poetry - a theme which recurs in his novels as well.

It is interesting to trace the attitude of Lawrence to industrialization through his poems which span the period 1912-1930. Lawrence was born in the village of Eastwood, in Nottinghamshire, an industrial area, the son of a collier. He had a first hand experience of the life of industrial workers. Lawrence chose to reject industrialization and industrial society.

His vision of industrial society becomes darker, more sinister and evil as we progress through his poetry.

Firstly, let us examine some literary themes which run through his poetry and which are symbolic of industrialization. One of the most commonly used literary topics is the machine.

In his first collection (1913) Lawrence refers to the "Chattering machine" complaining about the noise of the machine.

As we advance through his poetry the machine becomes sinister and animated. Thus in one of his LAST POEMS, "The Evil World Soul" we read:

- *Do not think that a machine is without a soul.*
- *Every wheel on its hub has a soul, evil,*
- *it is part of the evil world-soul, spinning.*

The second interesting use of a literary topos is the mill. The mill and the machine were the backbone of the British industry at the time of D.H. Lawrence. Indeed, we are reminded of the famous poem by William Blake (1757-1827) the Dark Satanic Mills which Lawrence used as a title for one of his poems. The argument of Lawrence is that the mills of the twentieth century are darker and more satanic than in the previous centuries.

The mills seem to symbolize both religious and secular oppression. In the poem "Mill of God" man is depicted trapped between heaven and earth, religion and society.

In one of his LAST POEMS,"Give us the Thebaid", we are told that

- *Modern Society is a mill*
- *that grinds life very small*

Another recurrent word laden with symbolism is robot. In the poem "The Gulf" robots are the "machine-spawn myriads", as opposed to natural men.

The robot image becomes more sinister and fearful in his later poems. Thus in his poem "Hold Back" we read of "the grinning and insatiable robots".

A frightful and tragic vision of horror and inevitability is depicted in his poem "Give us the Thebaid":

- *The upper millstone of the robot-classes*
- *the lower millstone of the robot-masses*
- *and between them, the last living human beings*
- *being ground exceeding small.*

The frightening implication in this poem is that modern industrial society, the mill, has crushed and levelled individualism and natural human life.

The sinister aspect of the robot culminates in the poem "The Evil World-Soul" where it becomes synonymous with evil:

- *The Robot is the unit of evil*
- *And the symbol of the Robot is the wheel revolving*

Lawrence treated the theme of industrialization in symbolic and metaphysical terms but also in realistic terms. In some of his poems we get a realistic picture of the factory and car fumes which fill the atmosphere. In his poem "The Cities" we read:

- *In the cities*
- *there is even no more any weather*
- *the weather in town is always benzine or else petrol*
- *fumes*
- *lubricating oil, exhaust gas.*

A major theme in Lawrence's poetry is man, the product of his industrial era. In one of his early poems, "Man who Died" we encounter two key words "mechanical" and "dead" which are associated with both man, the industrialist, and man, the factory worker.

Industrialization brought about the death of the rural society and the extermination of old customs, way of living, traditional crafts and arts and rural values. Industrialization created the large conurbations, the slum-besotten and fume-filled towns and cities. It broke our traditional links and roots with nature and land. The technological inventions and scientific discoveries can not compensate for the loss. Thus, Lawerence insists that the industrial, scientific society produces "dead" men:

- *The dead give ships and engines, cinema,*
- *radio and gramophone,*
- *they send aeroplanes across the sky,*
- *and they say: Now, behold, you are living the*
- *great life!*

The poet, however, calls this life a "stupendous life".

As far as Lawrence is concerned both the industrialists as well as the working class are "dead".

Lawrence is more sympathetic but equally disgusted with the exploited working class:

- *Oh I have loved the working class*
- *Where I was born,*
- *and lived to see them spawn into machine-robots*
- *in the hot-beds of the board-schools and the film.*

The plight, the helplessness, the nightmarish routine and inescapability of the life of a factory-hand is dramatically caught in his poem "The People":

- *when, in the streets of the working quarters*
- *the stream past, stream past, going to work;*
- *then, when I see the iron hooked in their faces,*
- *their poor, their fearful faces*
- *then I scream in my soul, for I know I cannot*
- *cut the iron hook out of their faces, that makes them so*
- *drawn*
- *nor cut the invisible wires of steel that pull them*
- *back and forth to work,*
- *back and forth, to work*
- *like fearful and corpse-like fishes hooked and being played*
- *by some malignant fisherman on an unseen, safe shore*
- *where he does not choose to land them yet, hooked fishes*
- *of the factory world.*

The poet, himself, feels he cannot help them. They are hooked by the invisible, malignant fisherman, industrialization.

Lawerence's vision of society and man becomes more tragic and nightmarish in his LAST POEMS

Lawrence, himself,lived through the First World War (which is not treated in his poetry); his marriage to Frieda was not a happy one; his novels were met with hostile criticism; his self-exile and wanderings around the world; his constant frail health and the confirmation of tuberculosis in 1925 - all these were factors which shaped a disillusioning image of man and society. In his poem "Love thy Neighbour" Lawerence lost faith in man; man has become a "thing":

- *I love my neighbour*
- *but*
- *are these things my neighbours?*
- *these two-legged things that walk and talk*
- *and eat and cachinate, and even seem to smile*

There are moments when like "a cry in the wilderness" he prophesizes the fall of the machines and the abolition of industrialization.

Eventually he realizes that the evil of industrialization has pervaded and contaminated even the poet himself:

- *then I know*
- *that with so many dead men in mills*
- *I too am almost dead*
- *I know the unliving factory-hand, living-dead millions*
- *is unliving me, living-dead me,*
- *I, with them, am living dead, mechanical enslaved at the machine*

The industrial man is lulled to his deadly sleep by dwellings, wages, board-school education, hapenny newspaper intelligence and black and white cinema. The all-pervasive evil of the industrial society has reached the soul of man:

- *And now, the iron has entered into the soul*
- *and the machine has entangled the brain, and got it fast*
- *and steel has twisted the loins of man,*
- *electricity has*
- *exploded the heart.*

This brief review of the treatment of industrialization in the poetry of D.H. Lawrence has shown, I trust, that Lawrence chose to adopt a totally negative attitude to industrial society, industrial man and industrial values.

On purpose he chose to omit the positive side and effects of science and technology.

Although he lived during the optimistic Victorian era he became disillusioned with the society and its values.

Eventually he created such a satanic, monstrous image of industrialization and its values that the alternative that Lawrence offers to his readers (i.e. return to nature, to natural life and our rural roots) seems meagre enough. Like Milton Lawrence created a more powerful, more interesting persona of the villain than the angelic alternative.

An unusual surface formation on Mars

G. Florides
Instructor, HTI

Mars is the fourth planet of our solar system. With a diameter at equator of 6787 Km orbits the Sun at a distance of 227.9 million Km, once every 687 days. Its rotation period is 24 hours and 37 minutes.

The surface of Mars was explored with cameras on the Mariner and Viking missions. The photographic exploration revealed a lot of detail of the surface formations of Mars and gave a lot of data to be studied for years.

One of the most unusual formation is the one that is imaged on at least two clear pictures of the Cydonia region of Mars. These images were taken by Viking 1 cameras and were filed in 1976 with the numbers 35A72 (meaning orbit 35, camera A and 72nd frame of image data) and 70A13. This formation lies at a latitute of 41^0 north and 9^0 longitude.

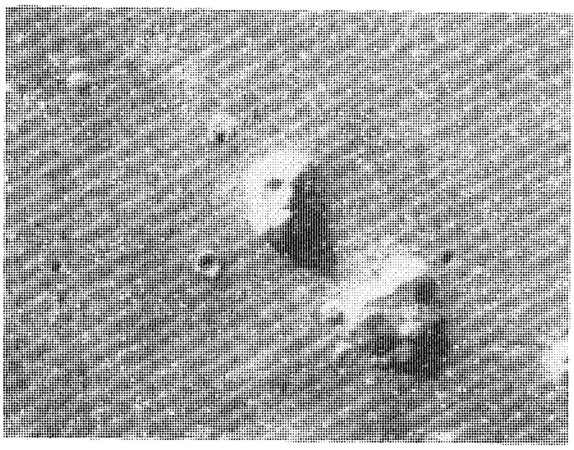


Image 35A72 (National Space Science Data Centre)

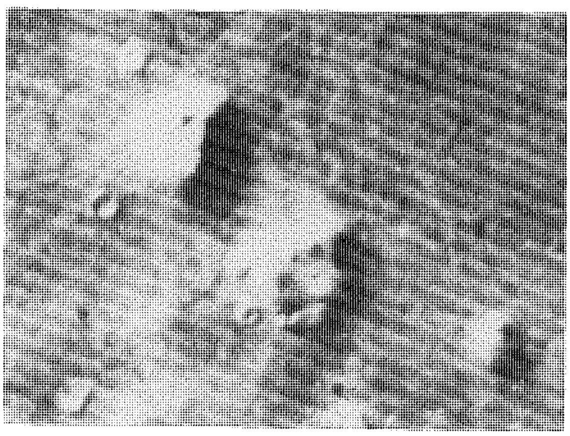


Image 70A13 (NSSDC)

Before we proceed to describe this formation, the way that the images were sent back to Earth will be explained in a general way. Every Viking image covers 54.4 x 49.6 Km. This area is covered by 1.27 million picture cells (pixels), ie marks. Every pixel therefore covers an area of 45.7 x 47.2 m and so the detail of the image is limited to these measures. Also every pixel has a shading number that was sent back to Earth in an 8-bit coding. This number is a measure of the reflectance of the corresponding surface. The 8-bit coding corresponds to 256 shades. The image can be reconstructed by assigning colours to every number, either shades of black and white or different colours for every number (fig. 1). It must be pointed out that every pixel gets a shade which is representative of the average light of the area covered and therefore no detail is indicated at that pixel and hence a stair-step like image results.

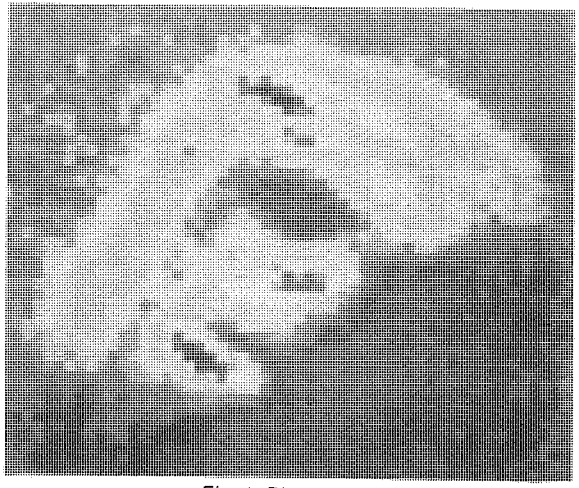


Fig. 1 Pixel shading

The aim now is to construct a three dimensional representation of the formation to match as accurately as possible the actual object.

The fact that there are two images available of the same formation will help us in estimating the height and shape of the object. On every NSSDC image the sun angle from vertical (INA^0) and the sun angle to north (Az^0) is indicated. So we have:

Image	INA^0	Az^0
35A72	79.93	88.55
70A13	62.59	86.53

Therefore by trigonometry the height of different points (fig. 2) can be calculated from the length of their shadows and is as follows:

point	Height m.
A	280
B	300
C	180

If now, points with the same shade are

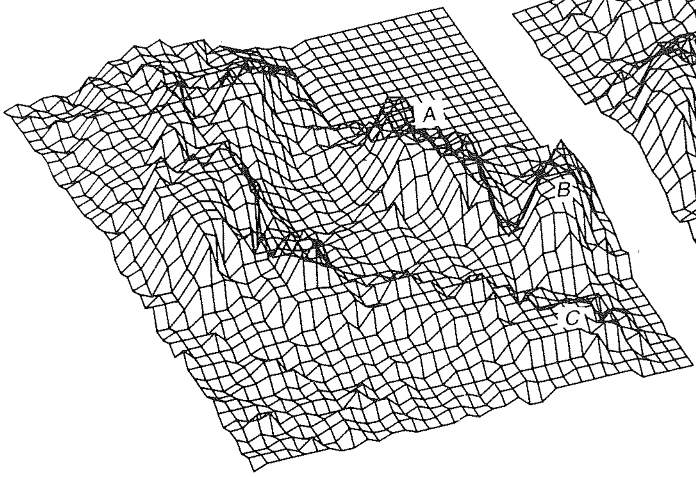


Fig. 2 3D-Mesh, View point -5, 3, 5

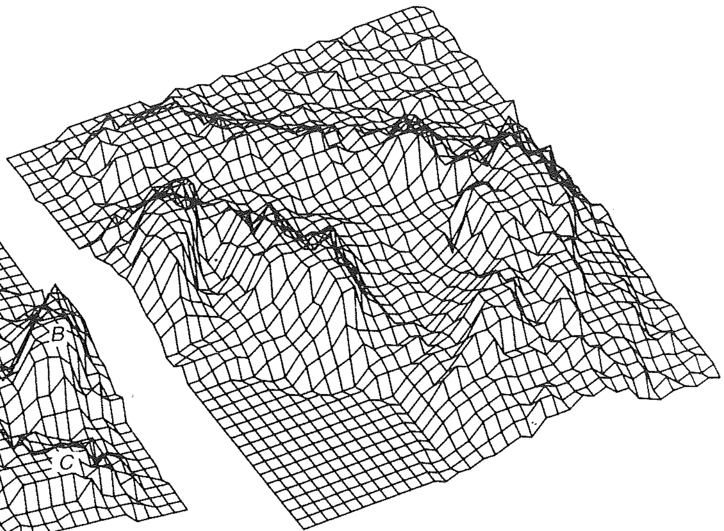


Fig. 3 3D-Mesh, View point 5, -3, 4

considered to have the same height, and the data are fed to a computer, a three dimensional figure can be obtained. For this exercise Autocad 10 was utilized and a 3d mesh was contructed. The results are shown in the following figures (fig. 2 -fig. 4). The object is looked at from different view points and as can be seen the formation resembles the right half side of a face with long hair.

Another way to show what the formation looks like, is to group together points of equal height and use the Polyline command of the Autocad to draw every group at the appropriate height (fig. 5).

Finally a model can be constructed and by simulating the light conditions more data can be concluded for the formation especially for the half which is covered by the shadow. At first the formation which is clearly shown on image 35A72 is formed to scale and material is added to different points until the shadow matches the one indicated on the image (fig. 6).

Then if the light is simulated according to the conditions of image 70A13 it is seen that the shadow cast does not fill all the shadowed area of the formation. This means that other features must exist in the other half which produce the missing part. The height of these features must

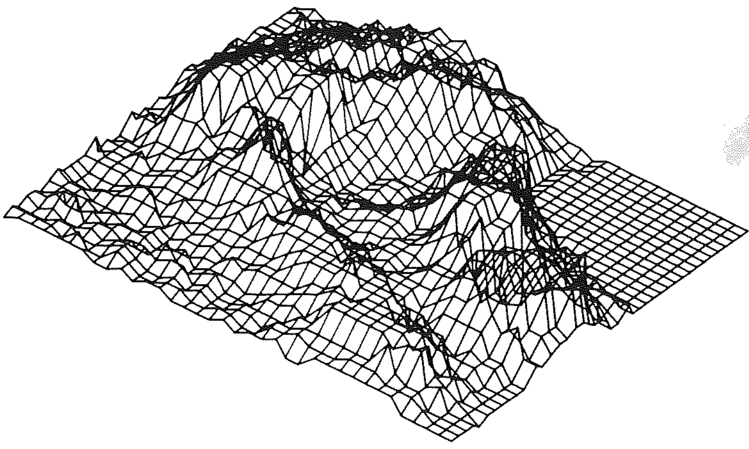


Fig. 4 3D-Mesh
View point -5, -2, 3

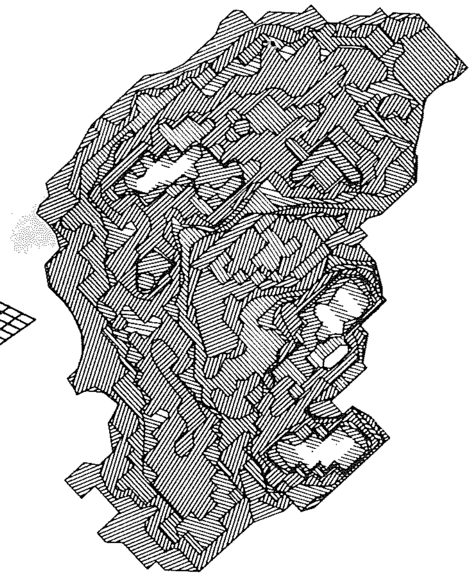


Fig. 5 Planes of equal height
View point 0, 0, 1

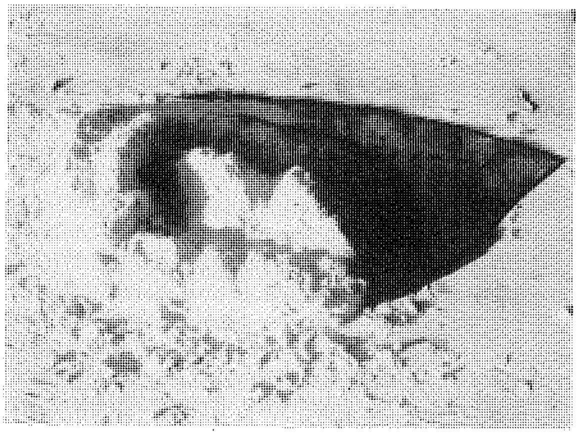


Fig. 6 Shadow of image 35A72

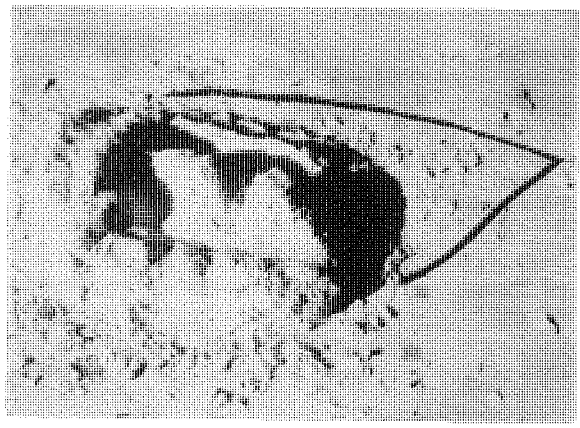


Fig. 7 Shadow of image 70A13

just exceed the height of the light path and therefore they cast their shadow (fig. 8) but are not recorded on the image 70A13 because of the low resolution of the image.

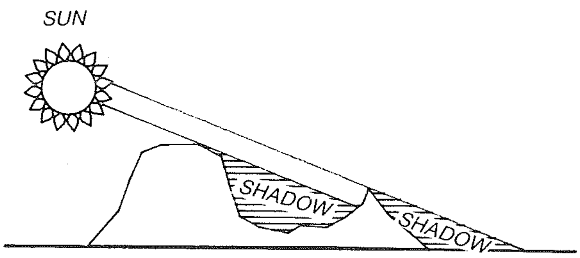


Fig. 8 Light path

With the above in mind the model is completed with the minimum amount of material in order to form the correct shadow. The final result is a symmetrical shape on the other half side (fig. 9). A number of investigators have also reached this conclusion by using image enhancing techniques.* Also the whole formation is tilted to the right side as looked from above.

Knowing that the size of the formation is about 2 Km, we can say that Nature can play a tricky game by forming features similar to a man's face with long hair, probably with a beard too since the height of the 'chin' is the same as that of the 'nose'. Or is it exactly what it seems to be? Finally it is worth mentioning that in the nearby area of the Cydonia 'Face' there are large Pyramidal formations.

* See 'Unusual Mars Surface Features' by Vincent DiPietro, Gregory Molenaar, Dr John Brandenburg.

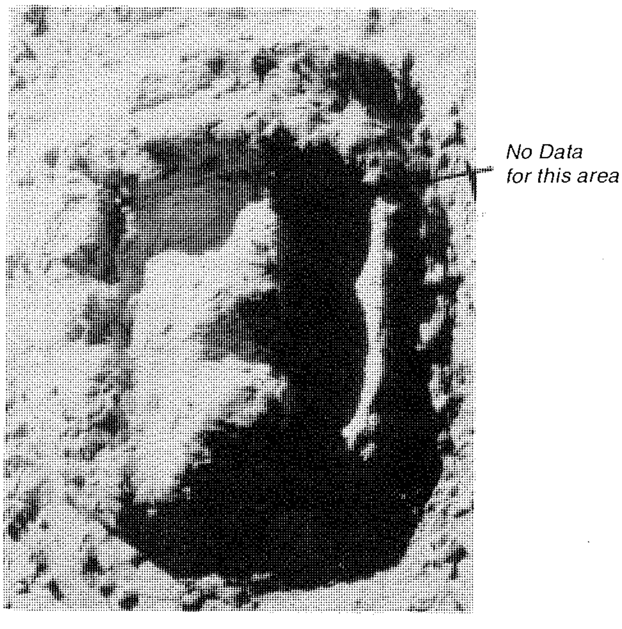


Fig. 9 The Formation

Variable stars

Savvas Koushiappas
student IMI, HTI

INTRODUCTION

Variable stars are stars whose brightness varies with time, ie are stars which do not remain constant in their outpourings of light and heat, but fluctuate in a peculiar manner, some periodically, others erratically. The simplest way to illustrate the typical behavior of any specific star is to plot the graph of the magnitude against time. This is known as "light curve". The variations can be seen in the light curve of the star and may be regular, with a period given by one complete cycle in brightness, or may be irregular or semiregular. The period range from hours to years, and the range between maximum and minimum brightness - the amplitude - is very wide.

Variable stars fall into three main categories: the eclipsing, pulsating and cataclysmic variables. These categories can be subdivied into many other types of variables. These many types also fall into three other main categories: the extrinsic variables where the variation results from some process external to the star as with some eclipsing binaries; with intrinsic variables the variation results from some change in the star itself as with pulsating variables; in other cases such as W Ursae Majoris stars the variation can result from a combination of intrinsic and extrinsic agencies.

Different types of variables can be distinguished by period and also by light curve shape, amplitude of the variation, depth of the minima, size and shape of the maxima, characteristic irregularities and by the continous or step-like changes involved. Spectroscopic and photometric measurements can be used to investigate changes in temperature, radial velocity and spectral type.

Eclipsing:

These are binary stars ie a pair of stars that are revolving about common centre of mass under the influence of their mutual gravitational attraction, whose orbital plane is orientated such that each component is totally or partially eclipsed by the other during each orbital period. The effect observed is a periodic decrease in the light from the system. The deeper minimum corresponds to the eclipse of the brighter star. The light curve[1] gives the period of rotation and from the depths and shapes of the minima it is possible to estimate the inclination of the orbital plane. The duration of the eclipses compared to the time between eclipses indicates the radii of the stars in terms of the distance between them. If the system isalso a double-lined spectroscopic binary[2] ie a binary star in which the orbital motions of the components give rise to detectable variations in radial velocity revealed changes in Doppler shift* in their spectral lines, the individual masses and radii of the stars can be calculated. Eclipsing binaries tend to be composed of large stars with small orbits and therefore the majority are close binaries.

There are three major classes of eclipsing binaries: Algol variables where the brighter component is always spherical, the Beta Lyrae stars where the brighter component is distorted into elliopsoid or may fill the Roche Lobe* and the W Ursae Majoris where the two components are actually in contact. Depending on the distance between them mass transfer may occur. This is a process occuring in close binary stars when one of the stars has expanded to such an extent that mass can be tranfered to its companion. This mass strike the more compact companion directly, or may orbit the star and eventually form a ring of matter - the so called accretion disc.

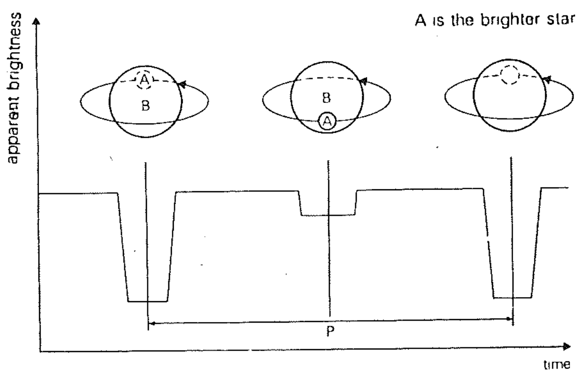


Figure 1 Schematic of orbits and light curve of an eclipsing binary.

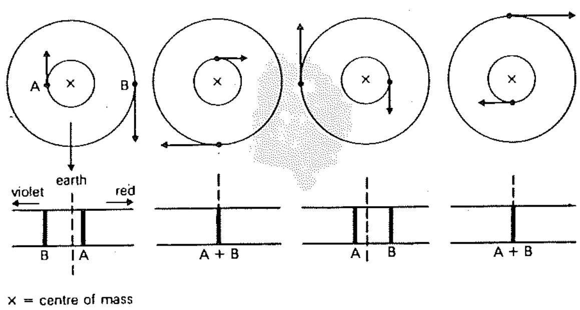


Figure 2 Doppler shifts of spectral lines at various orbital positions of spectroscopic binary

[1] *See figure 1*
[2] *See figure 2*

Pulsating:

These are variable stars that periodically brighten and fade as their outer layers go through a cycle of expansion and contraction. The period of light variations is equal to the period of pulsation and is normally approximately constant. The spectrum of the star also changes periodically due to, changes in surface temperature. The pulsation cycle is demostrated by variations in radial velocity*, temperature and radius.

A star pulsates because their is a small imbalance between gravitational force and outward directed radiation pressure so that it is not in hydrostatic equilibrium; the first tending to make the star contract, and the second causing it to expand. When these two forces are very nearly equal, some small internal, or possibly external distrubance could set the star into oscillation with a period depending upon the mass and density of the star. It is worth mentioned that the centre of the star is not involved in the pulsation, and that the maximum brightness occurs near the time of most rapid expansion, while minimum brightness occurs with the most rapid contraction. This is in contrast with any theory which assumes a simple pulsation of the entire stellar body. It might indeed seem that the star should be brightest and hottest shortly after the contractions has brought it to a state of highest density and pressure.

For most pulsating variables (probably exluding Beta Cephei stars) the driving force is a valve mechanism in the form of a region of changing opacity (=the ability of a gaseous, solid, or liquid body to absorb radiation), near the stellar surface where the pulsation amplitude is greatest. This is an ionization* zone in which atoms, mainly helium or hydrogen are partially ionized. Normally atoms become transparent letting heat escape as they are compressed. In an ionization zone the opacity increases with compression and the zone effectively acts as a heat engine: as long as it lies at the required depth below the surface it can drive the pulsations. If the zones are too close to the surface as in a very hot star or if too deep then the pulsations cannot occur.

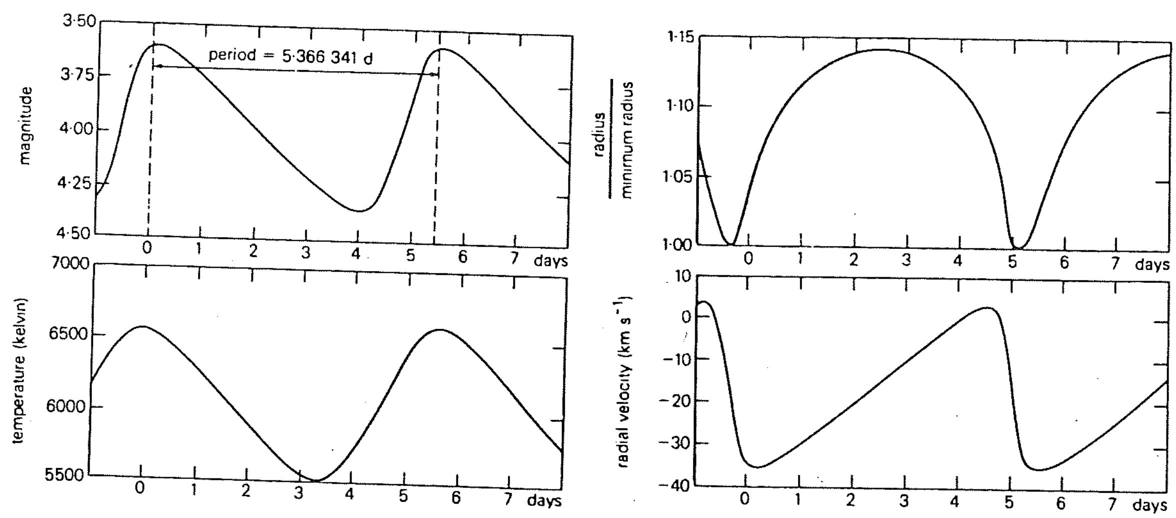


Figure 3 Variation in brightness, radius, temperature and radial velocity of expanding and contracting of a typical pulsating variable, the Delta Cephei

Cataclysmic:

Cataclysmic variables are stars that display a sudden large and unpredictable increase in brightness and then fades. Cataclysmic variables fall into three main types: the novae, dwarf novae and recurrent novae. Suprnovae are somewhat different and we will discuss this later.

First novae are stars that undergo a sudden increase in their brightness in a few days. This state of maximum brilliance lasts for few days and then the nova begins to fade and returns to its original brightness in few years. During the fading the brightness may not be uniformly and the star is showing minor pulsations. Even after reaching its minimum the star may still show some small variations for a number of years. Changes in the spectrum of the star are also observed simultaneously. From the study of their spectrum scientists found that there is a violent expansion of the outer layers of the star. At the time of maximum brighness the spectrum indicates the blown of shells of gaseous matter into space with enormous expansion velocities up to 2000 miles per second. After about a year the expanding cloud becomes visible in the telescope. Below is a typical light curve showing the different stages of a nova.

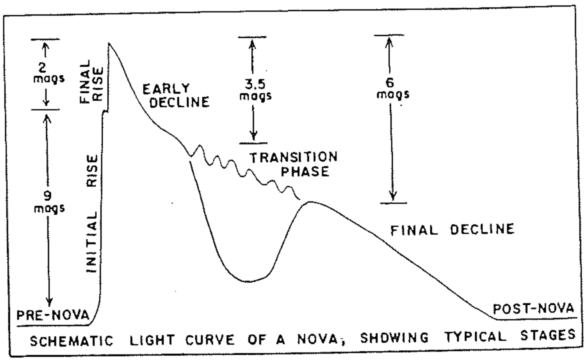


Figure 4

Dwarf novae is a small group of intrinsically faint stars that are characterized by a sudden increase in their brightness occuring at intervals of a few weeks or months. The maximum brightness lasts only few days. Most if not all dwarf novae are close binary stars in which the primary is usually a white dwarf (=a star that has mass below the Chandrasekhar limit (1.44 solar masses) and undergone graviational* collapse). The secondary is a cooled main sequence* star. Their masses are almost equal. Mass is flowing from the secondary to the primary and an accretion disc is formed arount it. The increase of the brightness is the release of graviational energy in the accretion disc.

Recurrent novae are stars which have shown more than one novalike outburst, at intervals from about 15 to 80 years. The change in brightness is smaller than with novae. Like novae they are thought to be close binary systems with a similar sort of energy outburst. Possibly all novae recur but the periods between outburst of the most are too long for more than one eruption to have been observed.

***Supernovae*:**

Despite the fact that supernovae are not actually variable stars we will describe briefly the phenomenon. Supenovae is the phenomenon of the explosion of a giant star which appears to be almost completely demolished. Supernovae are the greatest stellar cataclysms in the Universe. At the time of such an outburst the exploting star may brighten by several hundred million times brighter than the Sun, or 50 000 times the brightness of an ordinary nova!!! Unlike nova, the frequency of supernovae is much smaller, about one every third century in any one galaxy. In our galaxy in the last thousand years only four have been recorded.

Supernovae have been divided into five types although the vast majority fall into two types, the type I and type II. Type II occur in the spiral arms of spiral galaxies. The pre-supernova is almost certainly a supergiant* of more than eight solar masses and with a diameter of about 10 AU (AU is the astronomical unit and is the mean distance of the Earth from the Sun. It is equal to 149597870 km). Its iron core cannot generate energy by nuclear fussion and collapse catastrophically. The star's envelope is ejected violently possibly by a flow of neutrinos* from the collapsing core. Type I occur in both elliptical and spiral galaxies. They show bigger absolute brightness than type II. The cause of type I supernova is uncertain. The pre-supernova may be a white dwarf that accretes enough mass from a close companion to exceed theChandrasekharlimit or may be the core of a supergiant star that has lost its outer envelope and suffers a central explosion similar to a type II.

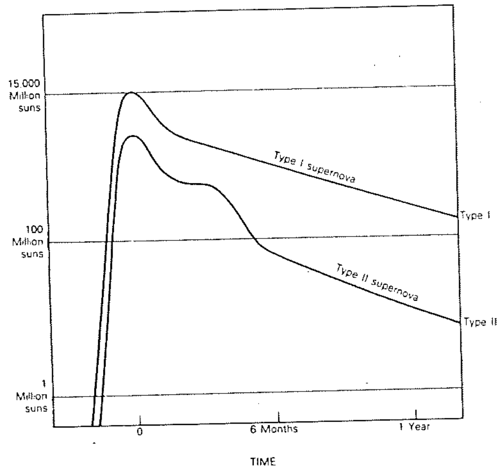


Figure 5 Light curves of type I and II supernovae

ACKNOWLEDGEMENTS

I would like to thank Mr. John E. Isles, director of the Variable stars section of the British Astronomical Association for his valuable advice in preparing this article.

GLOSSARY

Doppler effect: the change in the apparent frequency and hence the wavelenght of a wave motion as a result of relative motion of the source and the observer.

Radial velocity: The velocity of a star along the line of sight of an observer. It is calculated using the Doppler effect.

Gravitational collapse: The sudden collapse of the core of a massive star at the end of nuclear burning when its internal gas pressure can no longer support its weight.

Main sequence: The sequence which contains 90% of all known stars. A star enters the main sequence when it first achieves a stable state and its core temperature is enough for nuclear reactions to begin. An example is our star, the Sun.

Supergiant: The largest and most luminous type of star. Only the most massive stars can become supergiants and therefore they are rare. They are so bright that can be used as distance indicators in space.

Neutrino: A stable elementary particle with zero charge and spin 1/2. Neutrinos are hypothetized to have zero rest mass and according to the special theory of relativity travel at the speed of light. Neutrinos produces in nuclear reactions in the centre of stars.

Roche Lobes: These are imaginary surfaces surrounding a star or star system over which the gravitational field is constant. In a close binary star the equipotential surfaces of the components interact to become as shown in the figure. If one star has expanded so as to fill its Roche lobe it can only continue to expand by the escape of matter through the inner Lagrangian point L_1. This steam of gas will then enter an orbit about or collide with the smaller component. The system then is a semidetached binary: dwarf novae, Beta Lyrae stars and some Algol variables are examples. When both components fill their Roche lobes, as with W Ursae Majoris stars, they form a contact binary immersed in a common envelope of gas.

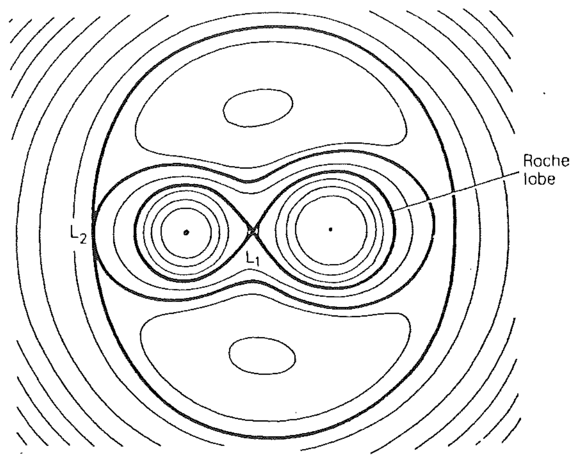


Figure 6 Equipotential surfaces of close binary star

REFERENCES

Burnham's Celestial Handbook, An observers guide to the universe beyond the solar system, 3 Volumes, Robert Burnham Jr., Dover

Amateur Astronomy, a comprehensive and practical survey. Colin Roman, Newnes

Norton's Star Atlas and Reference Hanbook 17th edition, Longman

A Dictionary of Astronomy, Pan

The Structure of the Universe, Jayant Narlikar, Oxford University Press

Calendar of activities academic year 1989-1990

D. Charalambidou-Solomi, D.E.S, BA(Hons), M.A.
Lecturer HTI

SEPTEMBER

● Enrolments for the academic year 1989-90 were: 60 for Civil Engineering, 63 for Electrical Engineering, 60 for Mechanical Engineering, 30 for Marine Engineering and 32 for Computer Studies.

12 students enrolled for the Medical Electronics Specialised Technician Course. Students were sponsored by WHO and CFTC

● Lectures commenced on Monday, 18 September.

● Research on "The Structural Behaviour and Material Properties of Fibre Reinforced Concrete" was undertaken by three members of HTI staff Dr. H. Stavrides, Mr K. Anastasiades and Mr N. Hadjigeorgiou.

● A 60- hour course in "Energy Conversion and Utilisation" commenced on 20 September. Fifteen participants from industry attended the course.

● The Cyprus Civil and Mechanical Joint Group of Professional Engineers (ICE/IMeChE) in collaboration with the HTI, the Industrial Training Authority of Cyprus and City University organised two courses: (a) Microcomputer Based Structural Analysis, August 30-1 September, and (b) Microcomputers in Highway and Traffic Engineering, 26-28 September.

Both courses were attended by people from the local industry and the Government sector.

● The HTI Director, Dr. Themos Drakos, attended the meeting of the IEE International Council in London from 4-8 September on the invitation of IEE London.

OCTOBER

● Dr. Christos Schizas, HTI Lecturer, attended the first IEE International Conference on Artificial Neural Networks held at the Savoy Place, London, 16-19 October. Dr Schizas presented a paper on the "Use of Artificial Neural Networks in Medical Diagnosis".

● The IEE Cyprus Centre in collaboration with the HTI and the Cyprus Industrial Training Authority organised two courses: "Unix/Xenix for Programmers and Users" and "Unix/Xenix: Support and Administration" between 23-27 October.

The courses were aimed at engineers and computer programmers working in industry and were developed and presented by the Microcomputer Unit, London. The duration of each course was 20 hours.

The courses were attended by 16 participants from local industries/organisations and 4 members for the Government Sector.

● The HTI Regional Training Centre in collaboration with the Extended Programme for Immunisation (EPI) of the World Health Organisation (WHO) organised and implemented a two week intensive course on the "Repair and Maintenance of Refrigerators" with 15 participants from various countries.

● Mr I. Michaelides, HTI Senior Lecturer, went to the Polytechnic of Central London on a staff exchange programme.

Dr. P. Votsis, Lecturer class II, from PCL replaced Mr Michaelides at HTI for 4 weeks.

● On 25 October the Director General of the Ministry of Labour and Social Insurance, Mr George Anastasiades, received an educational model of a Perkins Diesel Engine which was donated by Pilacoutas Ltd to HTI Mechanical and Marine Department.

● On Wendestady, 18 October the HTI staff and students donated blood for the needs of the General Hospital Nicosia.

● The Cyprus Civil and Mechanical Joint Group of Professional Engineers in collaboration with HTI, the Industrial Training Authority of Cyprus and the Polytechnic of Wales organised a course on "Geotechnics and Foundation Design".

The course was held between 31 October - 2 November and was of 24 hours duration. Participants were from the local industry and the Government sector.

NOVEMBER

● The IEE Cyprus Centre in collaboration with the HTI and the Industrial Training Authority of Cyprus, organised a course on "Electrical Services -Design, Installation and Maintenance', 4-18 November.

The course was aimed at engineers and technician engineers working in industry and was developed by IEE London.

The duration of the course was 36 hours and it was attended by 17 participants from industry and 2 Government employees.

● The HTI Regional Training Centre in collaboration with the WHO Expanded Programme on Immunization (EPI) organised a course on "Solar Refrigerator Repair" with 22 participants from Africa and the Middle East. Students were sponsored by WHO and UNICEF.

● Dr Christos Schizas, HTI Lecturer, was invited by the National Olympic Academy and gave a talk on "Information Technology and its Use in Modern Athletics" on 12 November.

● The first mid-semester exams were held 6-10 November.

● The HTI Director, Dr. Themos Drakos, attended a meeting of the International Council of the Institute of Electrical Engineers (IEE) in London as a guest of IEE.

● The Head of the Civil Engineering Department, Mr Demetris Lazarides, participated in the Conference of the British Institute of Civil Engineers (ICE) in London between 9-10 November on the invitation of ICE.

● The Head of the Mechanical and Marine Department, Mr George Iordanou, visited the Polytechnic of Wales, the Polytechnic of Central London and the University of Brunel between 16 November - 14 December.

During the same period Mr M. Thomas, Lecturer of the University of Wales, visited HTI.

● Dr. H. Masiar of the Slovak Technical University visited HTI between 22 November - 2 December according to the Cultural and Scientific Protocol between Cyprus and Chechoslovakia.

● The Head of RTC, Dr. A. Mallouppas, participated in a conference of the International Council of Medical Sciences from 2-3 November at the WHO Headquarters in Geneva.

● Dr Mallouppas, RTC Head, acted as a Chairman of the WHO International Council for the Education in the Field of Medical Equipment between 20-24 November in Campinas, Brazil.

● The HTI Astronomy Club organised a lecture in the HTI Amphitheatre on "In Search of Extraterrestrial Intelligence".

The lecturer was the President of the Club, Mr Andreas Achillides, HTI Senior Lecturer.

● UNESCO Day, an annual event, was celebrated on 16 November.

Students and staff visited the church of Panayia i Angeloctistos in Kiti village in Larnaca.

The priest, father Sotiris, talked on the historical and cultural value of the church. Students and staff offered voluntary work for the embelishment of the area around the church.

Prior to departure the HTI Director, Dr. Themos Drakos, spoke briefly on the significance of UNESCO and its international role in Education, Science and Culture. He also mentioned the special ties between UNESCO and HTI. The gathering voted a resolution to be sent to Director General of UNESCO.

DECEMBER

● The Cyprus Civil and Mechanical Joint Group of Professional Engineers in collaboration with HTI, the Industrial Authority of Cyprus and the Polytechnic of Wales organised a course on Civil Engineering Contract Procedure, 12-14 December.

The duration of the course was 24 hours. Participants came from local industry and the Government Departments.

● The HTI Astronomy Club organised a lecture on "Space Travels". The lecture was delivered by the President of the Club, Mr Andreas Achillides, Senior Lecturer at HTI.

● The break for Christmas holidays was between 24 December - 5 January.

JANUARY

● The Annual General Conference of the International Association for the Exchange of Students for Technical Experience (IEASTE) took place in Sao Paolo, Brazil, 11-20 January.

The Conference was attended by Dr. T. Drakos, Chairman of the National Committee of IEASTE-Cyprus and Mr P. Vassiliou, National Secretary.

IAESTE-Cyprus offered 25 training positions to various countries and secured 37 offers for Cypriot Students to receive training abroad during the current academic year.

Cyprus was chosen by secret ballot to host the 1991 IEASTE Annual Conference.

● The IEE Cyprus Centre in collaboration with HTI and the Industrial Training Authority of Cyprus organised a course on "An Introduction to Industrial Electronic Control" 22-26 January.

The course was developed and presented by Professor R.J. Simpson, Lanchashire Polytechnic, U.K. The duration of the course was 20 hours. It was attended by 26 participants from the local industry and the Government sector.

● The first semester exams were held 22 January - 2 February.

● From mid January - mid April the Cyprus Civil and Mechanical Joint Group of Professional Engineers (ICE/I MeChE) in collaboration with HTI developed and preseuted the course "(Construction Management" for civil engineers and architects. This course was part of a larger program aimed at university graduates.

The program was sponsored by the Industrial Training Authority and attended by 23 participants.

FEBRUARY

● Classes commenced on 5 February.

● The Cyprus Professional Engineers Association in collaboration with HTI and the Industrial Training Authority of Cyprus, organised a course on "Modern Techniques in Engineering Management for Productivity Enhancement" 19-23 February.

The course was developed and presented by Mr Terence Fielding-Smith of the Euromanagement & Technology Bureau, London.

The duration of the course was 24 hours and was attended by 31 participants from local industries and the Government Sector.

● The HTI Astronomy Club organised a lecture on "The Secret Powers of the Pyramides".

The lecturer was Mr A. Achillides, Senior Lecturer, and President of the Astronomy Club.

MARCH

● The IEE Cyprus Centre in collaboration with HTI and the Industrial Training Authority of Cyprus organised two courses on "The IBM PC for Engineers and Managers" between 23 March-4 April. Both courses were developed by the Microcomputer Unit, London, and were presented by Mr C. Theopemptou, HTI Lecturer.

The duration of each course was 20 hours. 36 engineers from the local industry and the Government sector attended the courses.

● Mrs Dena Charalambidou-Solomi, HTI Lecturer, was invited by the Cyprus Productivity Centre, Nicosia and gave two lectures on 22 March on "Business Correspondence", and "Report Writing" to staff and students of the Forestry Department, Ministry of Agriculture and Natural Resources.

● Mr. G. Vouloukos, psychologist, from Greece gave a lecture on "Regressive Hypnosis" on the invitation of the Astronomy Club.

● Sports Day was held on Thursday, 29 March. The finals of tournaments were held. Staff and students engaged in various sports activities and games.

APRIL

● The IEE Cyprus Centre in collaboration with HTI and the Industrial Training Authority of Cyprus organised two courses on "Software Testing: A Cost Effective and Practical Approach, 25-27 April.

The courses were developed by the Microcomputer Unit, London, and were presented by Mr Ronald Miller, authorised instructor.

The duration of each course was 20 hours. The courses were attended by 39 professionals from the local industry and the Government Sector.

● The Second Year Marine Engineering students went on a training trip abroad M/s "Princessa Marisa".

During the voyage Limassol-Haifa-Limassol students performed two-hour shifts in the engine room.

The trip was subsidised by Louis Tours, the ship owners.

- Dr. Christos Schizas, HTI Lecturer, was appointed visiting professor by the Indianapolis University, U.S.A.

  Dr Schizas plans to take up lecturing duties during the next academic year.

- Mr Nicos Kathitziotis, Lecturer, attended an intensive training course on experimental research as applied to disposing secondary effluents of wastewater treatment plants, and the effects of these effluents on the soil and the environment in geneval.

  The training was at the Autonomous University of Barcelona sponsored by the Community of Meditteranean Universities.

- The Cyprus Civil and Mechanical Joint Group of Professional Engineers in collaboration with City University, HTI and the Cyprus Industrial Training Authority organised a course on "Project Management in Construction" from 23-26 April.

- Mr Stavros Anastasiou, Head of Electrical Engineering Department, visited the University of Brunel from 23 April - 18 May on a staff exchange programme.

  Mr Thomas Thomson, Senior Lecturer from the Brunel University, replaced Mr Anastasiou at HTI.

- The second mid-semester exams were held between 2-6 April.

MAY

- The HTI staff and students donated blood on Tuesday, 8 May for the needs of the Blood Bank of the Nicosia General Hospital.

  This was the second time in this academic year that HTI staff and students donated blood.

- The Annual Graduating Students Dinner was held at the Philoxenia Hotel on Thursday, 10 May. The Dinner was honoured by H.E. the Minister of Labour and Social Insurance Mr. J. Aristidou, and the Director General of the Ministry of Labour and Social Insurance, Mr George Anastasiades. During the Dinner the HTI Director, Dr. Themos Drakos, proposed a toast to H.E. the President of the Republic, Mr George Vasiliou.

  Mrs Lia Mylona, the Director of the Industrial Training Authority, proposed a toast to HTI graduating students. Mr Martinos Kyprianou, President of the HTI Students Union acknowledged.

  The Dinner was also attended by HTI staff and official guests of HTI from the local industry.

- The HTI Astronomy Club has scheduled a lecture for 22 May in the HTI Amphitheatre on "Trial by Fire, the Ancient Mystery".

  The lecturer will be Mr A. Achillides, President of the Astronomy Club.

JUNE

- The final exams for first and second year students are scheduled for 5-15 June.

- The Graduation Ceremony will be held on Wednesday 4 July. H.E. The President of the Republic, Mr George Vasiliou, has been invited to attend.

We Have the Experience and the Products to Offer Complete Solutions

10 years

We Are #1

WPC Ltd is a complete business resource offering a comprehensive range of high quality computer systems, office equipment and services, from the high end supermicrocomputer multiuser environments to Local Area Networks and from Typewriters to High Volume Copying Systems.

WPC employs 63 people in Nicosia and Limassol including 25 engineers and software specialists.

IBM Authorized Dealer	IBM Authorized Dealer	MINOLTA	COMPAQ	EPSON	Acer
Personal System /2	Typewriters	COPIERS TELEFAXES	COMPUTERS	PRINTERS	COMPUTERS LASER PRINTERS

WPC

NICOSIA HEAD OFFICE:
Neoelen Marina Building, 10 Katsonis str.,
P.O. Box: 4973, Tel.: 449398, Tlx: 4805, Fax: 367263

LIMASSOL BRANCH:
Ayias Zonis & Archimidous 16
P.O. Box: 5094, Tel.: 53232, Fax: 54257

SKF The largest manufacturer of ball and roller bearings

S K F is an international group with factories in twenty countries, an international sales network, and its own service organisation spread around the world.

S K F bearings are made in 8,000 basic types and sizes and many thousands of variants ranging from 3mm to several metres in outside diameter and from a weight of 0.036 grammes to more than 6,000 Kg. There are S K F bearings which can run at a speed of 400,000 r.p.m. and others which at low speed can carry loads of more than 2,000 tons.

S K F research efforts strech from theory right through applied mathematics by computer to manufacturing process and product development. To illustrate the degree of accuracy required we may cite the example of any one medium sized bearing where ball diametres must not deviate more than 0.00002in., and where errors in sphericity in one particular ball must not exceed 0.00001in.

MUCH MORE THAN BEARINGS

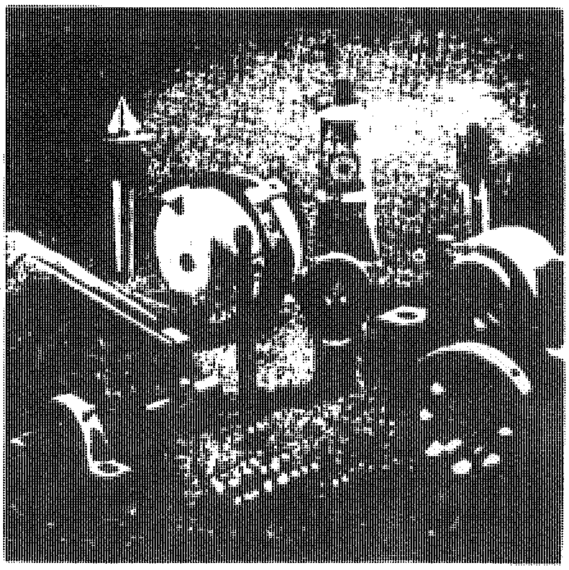
BALL BEARINGS

ROLLER BEARINGS

CASTINGS

MACHINE TOOLS

TOOLS



TEXTILE MACHINERY

COMPONENTS

PLANETARY ROLLER

SCREWS

FLUIDICS

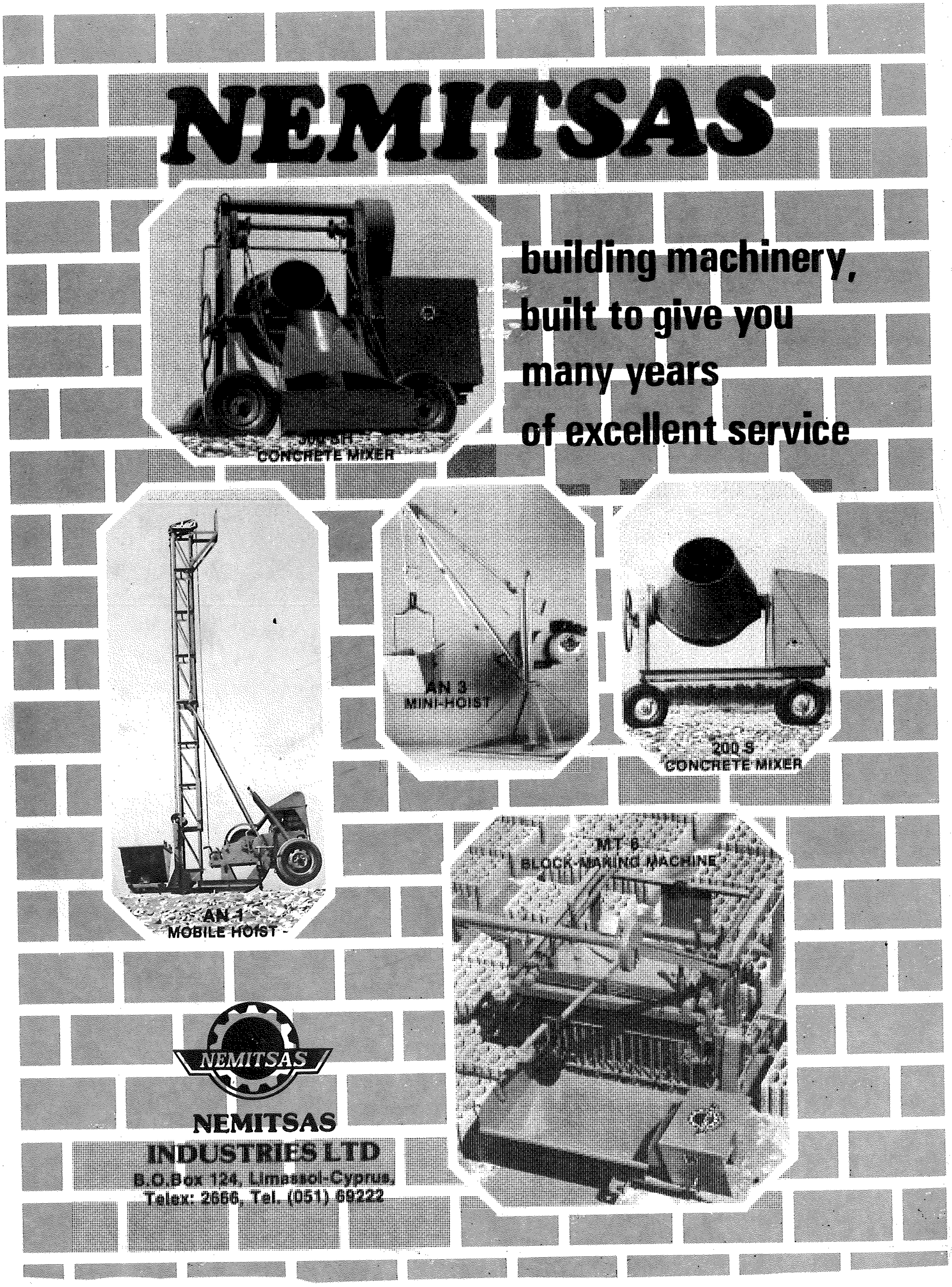
SKF

SKF Best possible service to customers

Research and development in the S K F group is applied in three directions. The first is the development of production technology the second is the development of new products and the third is a continuous process of developing the traditional product ranges to changing market requirements.

S K F faces strong competition in all the most important industrial countries. It is, however, true to say that S K F is foremost in the field of roller bearing engineering, in addition to being the most important exporter of ball and roller bearings.

S K F has attained this pre-eminent position for several reasons. One of them being that S K F was the first bearing firm to undertake systematic theoretical and experimental research in ball and roller bearing engineering.


NEMITSAS
building machinery,
built to give you
many years
of excellent service
CONCRETE MIXER
AN 1
MOBILE HOIST
AN 3
MINI-HOIST
200 S
CONCRETE MIXER
BLOCK-MAKING MACHINE
NEMITSAS
NEMITSAS
INDUSTRIES LTD
B.O.Box 124, Limassol-Cyprus,
Telex: 2666, Tel. (051) 69222