Review

THE HIGHER TECHNICAL INSTITUTE

Number 26 October 1997 Nicosia Cyprus

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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 - Education-Scientific and Cultural Organisation (UNESCO), the International Labour Office (ILO). Cyprus Government Executing Agency: The Ministry of Labour and Social Insurance.

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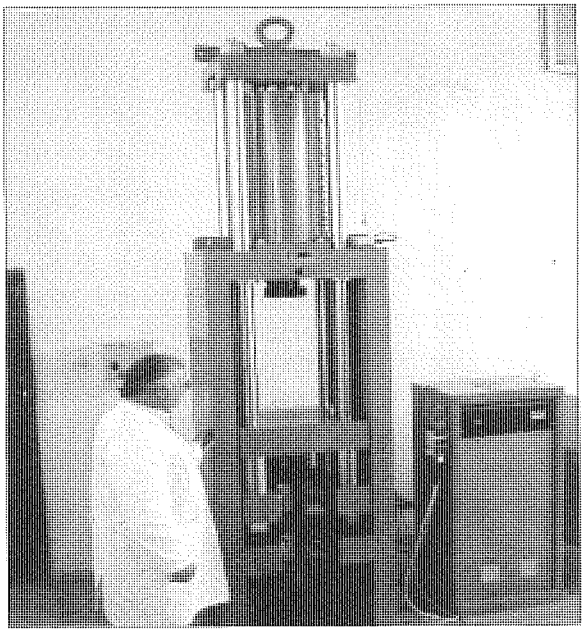

The 100 tonne Tension-Compression Testing Machine recenlty acquired by HTI. *Photo by Dr H. Stavrides*

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1997 HTI Graduation Ceremony

The 27th Graduation Ceremony of the Higher Technical Institute was held on 3 July at the Cyprus International Conference Centre.

The Minister of Labour and Social Insurance, Mr Andreas Moushouttas, honoured the Ceremony with his presence and, on behalf of the President of the Republic, awarded the Presidential Price of £2000 to the graduate of the highest overall performance, Mr. Theodotos Andreou. Mr Moushouttas also handed the sum of £2000, the President's annual donation from his personal budget in aid of the needy students of the Institute.

The Minister of L.&S.I. awarded the diplomas to the one-hundred-and forty-nine graduates, while the Director of HTI, Mr Demetrios Lazarides, awarded the prizes sponsored by industry and professional bodies to the graduates who excelled in their academic studies.

The Ceremony was also attended by the Director General of the Ministry of L.&S.i., Mr Nicos Symeonides, the Chief General of the Cyprus National Guard, Mr Vorvolakos, guests of the Institute, and students' relatives.

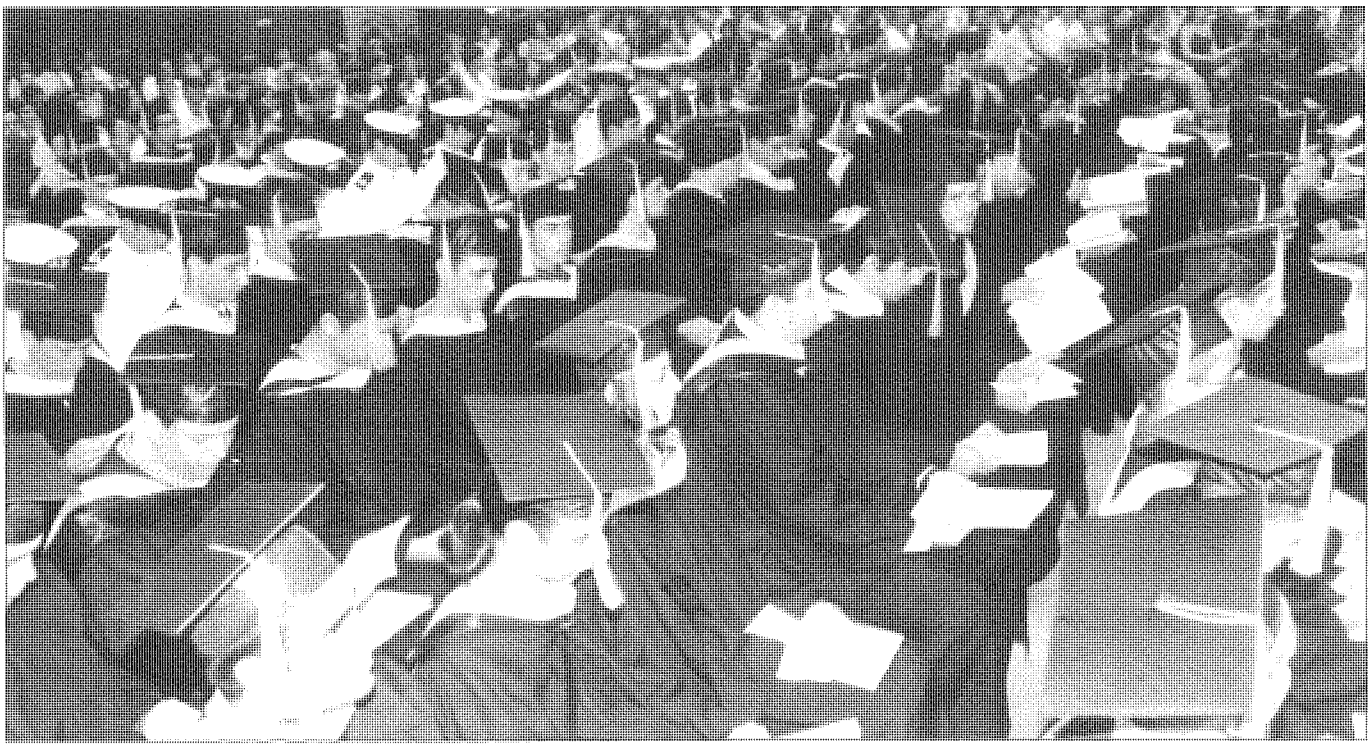
The President of the Student Union, Mr Andreas Dermosoniades, addressing the gathering highlighted the excellent academic performance and achievements of HTI. However, he went on to add that the Institute needed re-structuring and upgrading in order to meet future challenges and remain competitive within the educational community.

Additionally he stressed the need for establishing a special sub-degree level post for technician engineers in the civil service for HTI graduates.

The main speaker was the HTI Director who thanked the Minister and the Director General of L.& S.I. and other dignitaries for honouring the Ceremony with their presence.

Firstly, Mr Lazarides underlined the fact that HTI, in addition to its three-year programmes of studies, organised in co-operation with the Industrial Training Authority of Cyprus, other professional bodies and overseas educational institutions 28 short courses which were attended by 463 professionals.

Mr Lazarides went on to highlight the academic achievements of the Institute and its vital contribution to the development of the industry of the Island. He also pointed out that HTI has been involved in applied



research and other programmes funded by EU and Greece.

Currently the main research programme, the Director added, is the salination of water by harnessing solar energy. For this programme HTI is co-operating with researchers from Greece, Portugal, Italy, and Jordan. The budget of the project is estimated around £100,000 and is funded by the European Union.

With government financial support HTI personnel was enabled to become involved in various research projects and offer consultancy services to the Cyprus industry and in particular in the testing of building materials.

Mr Lazarides thanked the Ministry of L. & S.I for its support so that

HTI could acquire a multi-purpose Palais de Sports. Work on the building of the Palais de Sports, which would accommodate 800 spectators, has already started. Its total cost is estimated around £800,000.

The Director announced that the new HTI Library has been completed and it is now being furnished. Very soon the new Library with upgraded facilities will be ready to serve both the students and the public.

Additionally, Mr Lazarides said, the Ministry had spent £750.000 on new laboratory equipment and around £1,500.000 on hardware and software in its efforts to renew and upgrade laboratory facilities.

Mr Lazarides went on to pin-point three problems that created unrest in the smooth operation of HTI in the present academic year. These problems were: (a) lack of legislation for the status and operation of HTI. On this issue a bill was drafted and it remains to be forwarded to the Parliament for ratification; (b) need for the creation of a sub-degree level post for technician engineers within the civil service for HTI graduates, and (c) the demand for professional recognition of HTI graduates. This issue seems to have been resolved by the passing of the law 22 of 96 which facilitates the registration of HTI graduates with ETEK.

The Director concluded that despite these problems, the future of HTI seems bright because of its acknowledged contribution over the twenty seven years of its life. "We are optimistic over its future," the Director added, "for HTI is indeed literally the blood-donor of the Cyprus industry having offered 3,630 graduates to the work marked and its constribution has been vital in our efforts to upgrade the technology sector of our country."

Mr Lazarides ended by thanking first of all the President of the Republic for his generous personal donation of £2.000 for the needy students of HTI, as well as the various organisations and industries for their support by offering dorations, prizes and scholarships.

Finally, the HTI Director, on behalf of the Government and the Ministry of L.&S.I. wished the graduates professional success and personal happiness.

THE HAZARDS OF ELECTRIC AND MAGNETIC FIELDS AT EXTREMELY LOW FREQUENCIES

S P Spyrou, BSc, Ceng, MIEE, Senior Lecturer, HTI

1. Introduction.

Extremely low frequencies cover the range from 30 to 300 Hz and are mainly due to power generation, transmission, distribution and utilisation.

2. Electric and Magnetic fields

2.1. Electric Fields.

The unit for the electric field strength, E, is the volt per metre (V/m). It is usually much easier to measure the electric potential (V) that exists between two points rather than the electric field strength, because V is independent of the geometry of a given system e.g. location or size of conductors. V is invariably specified in by the level or number of volts above earth potential.

The relationship between these two quantities may be explained by considering a simple situation where the potential, V between two plates separated by a distance h m. The electric field strength is given by:

$$E = V/h$$

Any electric charge will produce an electric field, E, at all points in space. E is characterised as a vector in that it has both magnitude and direction. If another charge q is placed in this electric field, it will experience a force, F, given by:

$$F = qE$$

The direction of the force on a positive charge is in the direction of E, while on a negative charge is opposite. In an electrically conductive material such as the living tissue these forces will set up charges in motion thus forming induced electric currents.

The unit of the electrical current (I) is the ampere (A) and of the current density (J) is the ampere per square metre (A/m^2).

The relationship between the electric field and the current density is given by:

$$J = \sigma E$$

where σ is electrical conductivity of the medium.

The unit of σ is the siemen per metre (S/m).

Living tissue has a low frequency conductivity within the range 0.01 - 1.5 S/m.

2.1.1. Electric field measurements.

A meter called a free-body or dipole meter is the instrument developed for the measurement of electric fields.

The principle of operation of these instruments is the induction of a current in conducting surface.

It consists of two conducting halves (dipole) and an electronic measuring device which can measure the current induced in the two halves when these are placed within the unknown electric field.

These meters tend to perturb the field to be measured and give rise to errors which should be taken into account when accurate results are required.

Another potential error is due the field perturbations caused by the presence of the instrument operator. It is usually recommended that the operator-to-meter distance is at least 2.5m.

2.1.2. Electric Field Sources

a) Natural sources

The only natural source of electric fields is the vertical electric field present in the lower portion of the earth's atmosphere, as explained below.

Experiments have shown that there is a natural, vertical electric field present near the surface of the Earth. The origin of this field is the transportation of positive charges, carried by thunderstorm activity, from the ground to the upper atmosphere. The mean value of this highly fluctuating field is in the region of 130 V/m directed vertically downward. During thunderstorm this field can increase considerably and there are instances when this was measured at levels in excess of 130 kV/m.

b) Man-made sources.

Electric fields with frequencies in the ELF range are predominantly from man-made sources. These are produced during generation, transmission and distribution of electrical power or generated by the current carrying conductors supplying electrical energy for the various needs of the humans. The main sources of ELF fields found in open spaces are those produced by the electrical power generation, transition and distribution systems.

These fields have been investigated in may instances and it is possible to find data for all types of cable configurations. Figures L1 and L2 are examples of the distribution of the electric fields in the vicinity of transmission lines.

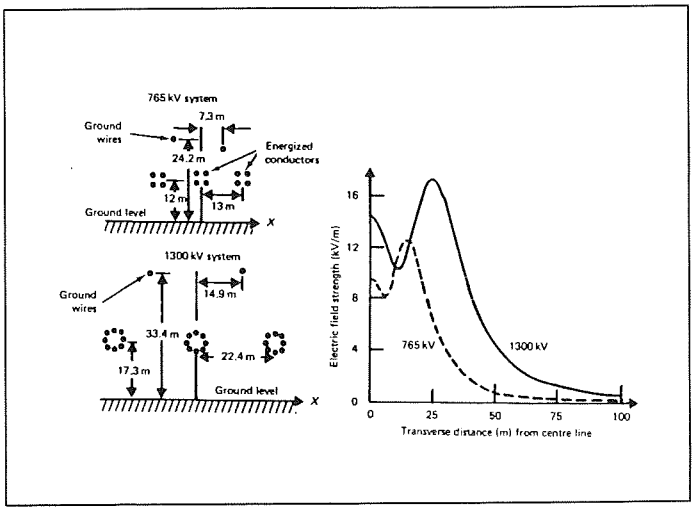


Figure L1. Calculated electric field strength mid-way between two towers supporting an electric power transmission line.

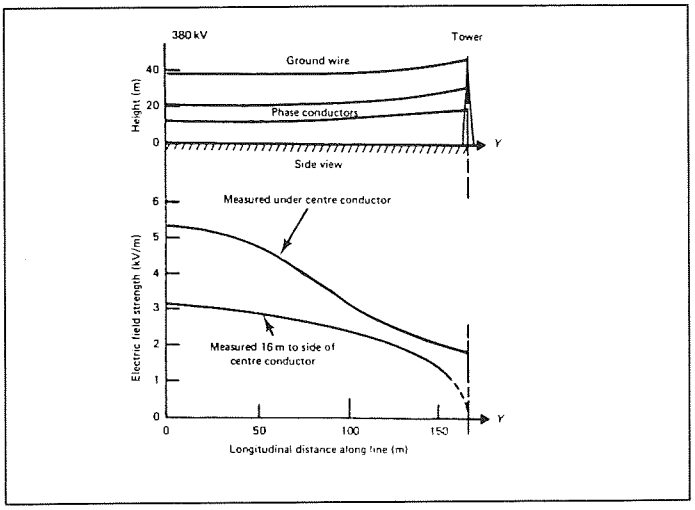


Figure L2. Measured electric field strength E_0 along the trace of a 380 kV double circuit line.

Tables E1 and E2 give the values of the fields produced under the transmission lines at various voltages and in a typical distribution substation.

Highest System Voltage (kV)	Electric Field Strength under line at midspan (kV/m)
123	1 - 2
245	2 -3
420	5 - 6
800	10 -12
1200 - 17	

Table L1.

Maximum electric field strengths at midspan under various configurations and voltages of electric power transmission lines.

Highest System Voltage (kV)	Electric Field Strength under Busbars (kV/m)
123	5 - 6
245	9 - 10
420	14 - 16
800	14 -1 6

Table L2.

Maximum Electric Field Strength in Substations.

At present there is a considerable amount of research in many countries under way to determine the actual exposure to electric fields of people working or living near transmission lines. It is, however, difficult to accurately assess these fields because the physical presence of these people will perturb the filed and measurements made on unperturbed field are much greater.

A considerable amount of data has been published on measurements under or in the vicinity of power lines. It is, thus, true to assume that the electric fields produced by the transmission and distribution lines can be assessed accurately from theoretical considerations. It is worth noting that the maximum electric field strength directly under the transmission line for a 250 kV system is only 2-3 kV/m.

2.2. Magnetic Fields.

Magnetic fields are produced by electrical charges in physical motion, since the commonest form of moving charges is the flow of an electric current, it can be said that the major source of man-made magnetic fields is the usage and distribution of electrical energy.

A magnetic field exerts a force on a moving charge, called Lorenz force, in a direction perpendicular to motion. This is an important property because the magnetic field will not interfere with the speed of a moving particle, it will only change its direction.

The expression for this force is:

$$F = qvB$$

Where v is the velocity of the particle, B is the magnetic flux density and q is the charge of the moving particle.

Magnetic fields are specified by two vector quantities, the magnetic flux density, B, whose unit is the Tesla (T) and the magnetic field strength, H, whose unit is the ampere/metre (A/m). These are, for a given medium, proportional to each other:

$$B = \mu_0 H$$

where $\mu_0 = 4.\pi.10^{-7}$

2.2.1. Magnetic Field measurements

There are two types of instruments that measure magnetic fields.

The simplest one, uses coils, called search coils, into which a voltage is induced. By measuring this voltage the magnetic field parameters are deduced. This type of instrument is fairly simple, cheap and accurate.

The other type utilises the Hall effect which is an application of the principle of deflection of moving electric charges when exposed to a magnetic field.

2.2.2. Magnetic Field Sources.

a) Natural sources

Sources of magnetic fields in the ELF range are from natural phenomena such as thunderstorms and solar activity. The magnitude of these fields is in the region of 0.01 mT (8 mA/m) and in exceptional cases may rise to 0.5 μT (0.4 A/m).

b) Man-made sources

Magnetic fields in the ELF range are produced in the home and the office by the cables distributing electrical energy and the various devices and appliances. These fields are usually low, about 0.3 μT (0.24 A/m).

Much higher intensities are produced in industry and under power distribution lines. Figure L3 shows the distribution of the field

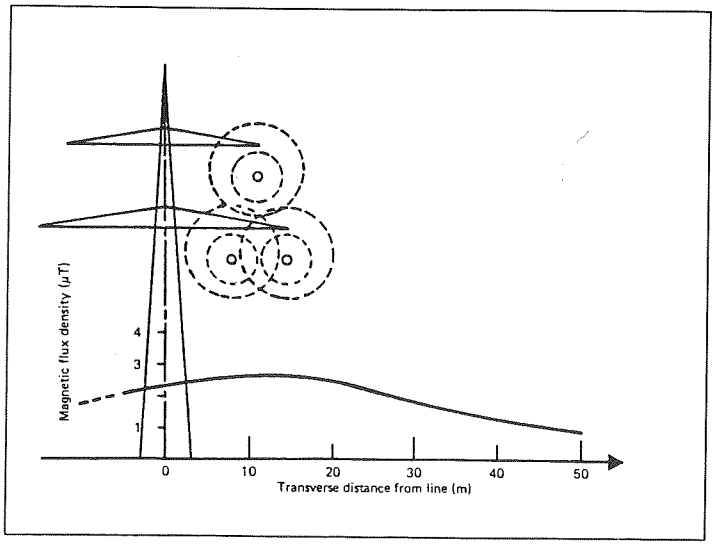


Figure L3. Magnetic Flux Density.

3. Electric and magnetic field coupling with living organisms.

Exposure of living organisms to electric and magnetic fields is usually specified by the unperturbed field strength. This value, although not correct, is easy to measure or to calculate. The actual field to which the organism is exposed is much more difficult to measure because the physical presence of the organism will interfere and perturb the field.

The data used for assessing the risks to humans of exposure to these fields where obtained in experiments where animals were exposed to uniform fields in confined spaces.

3.1. Theory of electric field coupling.

3.1.1. Static electric field.

When an object such as person or an animal is exposed to a static electric field, E_0, an electric charge will be induced on its surface.

This charge will now produce its own electric field E_1.

The magnitude and distribution of the induced surface charge is such that the sum of the two will be zero inside to body, while it will be additive at most points on the exterior surface.

3.1.2. Oscillating electric field.

When the object is exposed to an oscillating field at a frequency in the ELF range, it will have the induced surface charge, oscillating at the same frequency. As a consequence electric currents will be circulating inside the object's body. If the object is conducting, such as the case of a living organism, then these currents will set up an internal electric field.

In the ELF range the variation of the surface charge is slow and thus the induced current and electric field are very small and many researchers, have concluded that the exposure of the human body to LF fields will be the same as that to static fields.

3.1.3. Experimental data on electric field coupling.

A considerable number of a theoretical and practical papers have been written on this subject and a number of models have been developed that show the distribution of fields and currents inside the human or animal body. Examples are Figures 4 and 5.

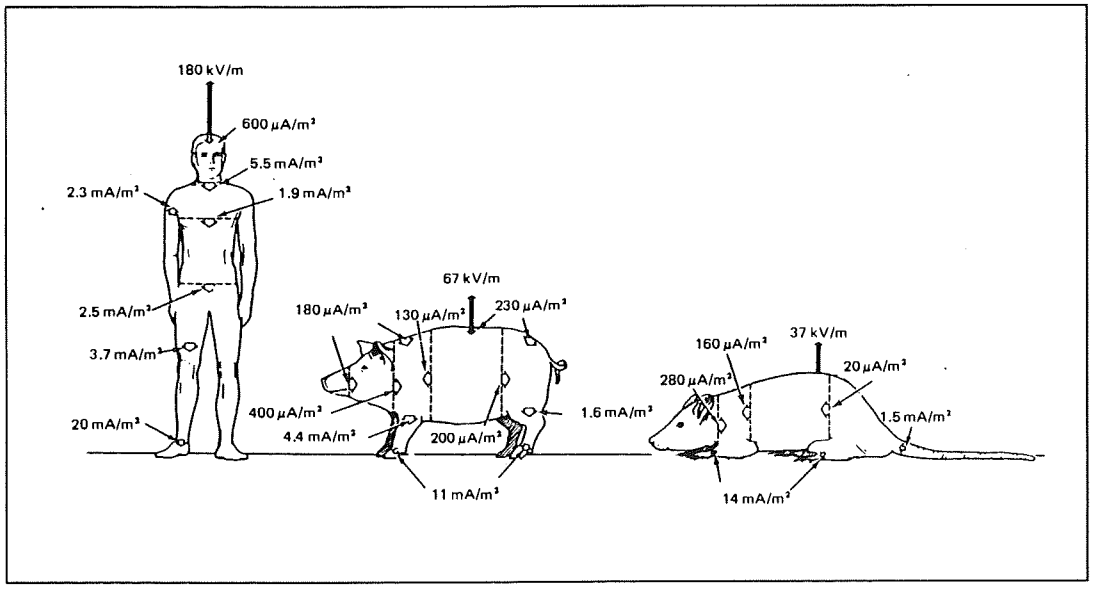


Figure L4.

Effects of a vertical electric field of 60 Hz and 10 kV on grounded human, pig and rat.

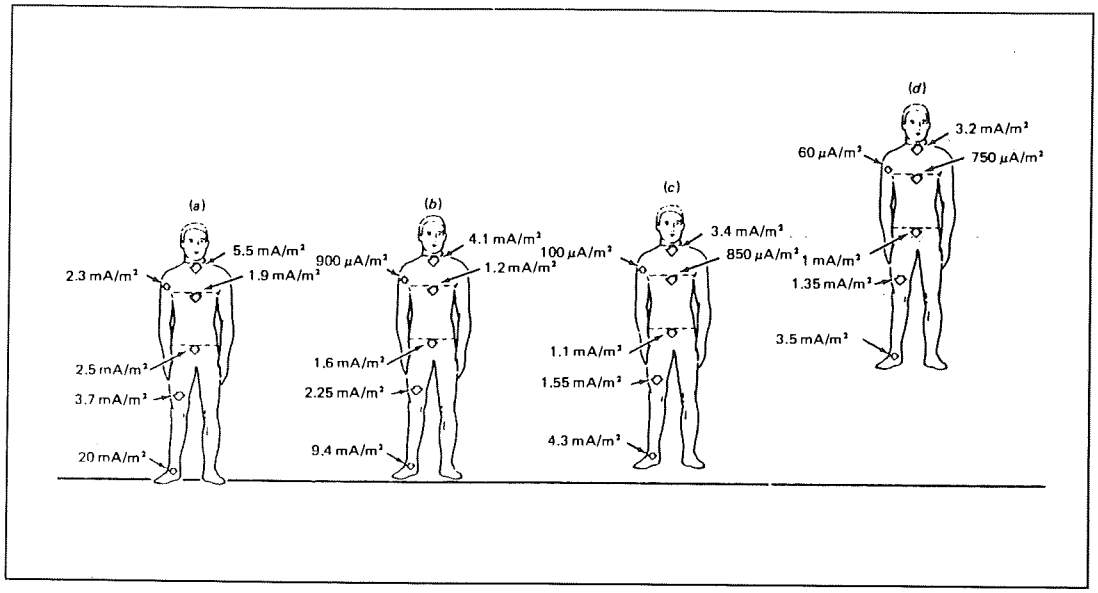


Figure L5.

Average axial current densities induced in a 1.7 tall person exposed to a vertical 10 kV/m, 60 Hz electric field.

3.1.4. Biophysical analysis of electric field coupling.

The electric field to which a person is exposed may be perceived by the person and the most widely known mechanism is the hair stimulation (piloerection) that is the production of oscillatory hair motion by the electric forces.

Another well known mechanism of interaction with biological tissues is the direct stimulation of excitable cells.

At cellular level this mechanism consists of the induction of a potential across the membranes of the excitable cells. This potential may be large enough to generate the physiological action potential, thus causing cell or fibre reaction. This accounts for the ability of living organism to perceive electric currents and possibly experience a shock (electric shock).

Experimental work supplemented by estimates showed that a current density in the tissue of 10-20 A/m^2 will excite action potentials in cells. In the case however of long nerve cells this may be lower.

Bernhardt proposed that the threshold current density for the stimulation of action potentials is 1 A/m^2.

In experiments involving the release of calcium ions from brain tissues show that there must be other mechanism of interaction between ELF electric fields and biological tissues besides the direct stimulation of cells.

Neurophysiologists and scientists are considering the view that the communication between the brain cells is affected by the extracellular electrical environment. Based on this idea Bernhardt suggests that external fields which induce internal fields comparable in strength to endogenous fields should be considered as unsafe. By considering ECG and EEG data he arrived at the conclusion that the induced current density should not exceed 1 mA/m^2.

There have been several attempts to develop models that can explain the interaction of biological tissues with ELF fields. At present none of these produces convincing results.

4. Protective measures from electric fields.

Protection from electric field exposure is relatively simple and effective in the form of shielding.

At this range of frequencies any conducting surface provides substantial shielding. A practical approach employed in a high field strength environment is the provision electrically conductive clothing.

The other method is to restrict access to areas where electric field strengths are large.

5. Capacitive discharge and contact currents.

Conducting objects placed in an electric field have potentials induced on and inside them and electrical energy stored in their capacitance. If two such objects are brought together then at the instant of contact capacitive

discharge occurs and a pulse of electric current will pass between them in order to reduce the potential difference between them. In cases where this difference is sufficiently high the discharge manifests itself as a spark. The discharge may be perceptible, annoying or painful.

5.1. Capacitive discharge.

Research on the subject of effects from discharging a charged object was performed using persons to discharge charged capacitors with their finger. The results briefly are:

- The voltage required to produce an electric field that is strong enough to exceed the dielectric strength of the insulating layers of the skin is about 450V.
- In cases where the voltage is higher a spark will be produced.
- When the finger is in actual contact with the object a longer discharge takes place discharging the two bodies to about 100V.

These effects are shown in Figure L6.

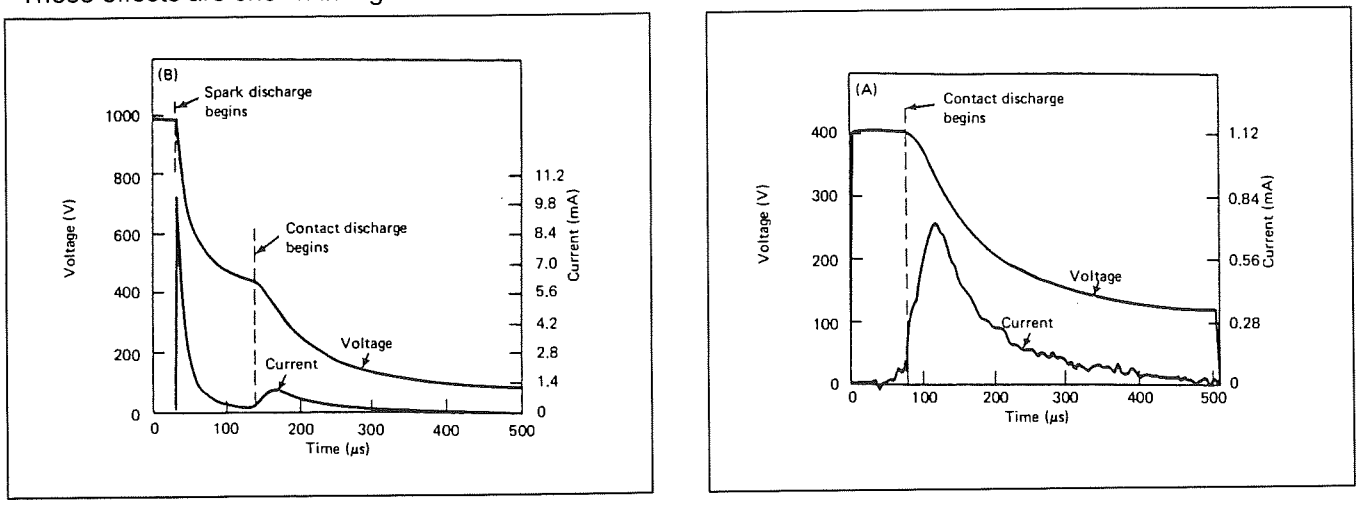


Figure L6.

Voltage and current waveforms for discharges to a person tapping an energised capacitor.

The following table gives typical values of capacitance of various objects.

Object	capacitance (pF)
Person	100
Small car	1000
Medium sized car	1600
Large station wagon	2000
Bus	2700
Large truck	3600

Table L3

Capacitance of some objects that may be found near high voltage transmission lines.

5.2. Steady state currents.

Once contact is made between the two conducting bodies a steady state current of the same frequency will be exchanged between the two bodies. This current under certain condition could be large enough to become dangerous.

If now a grounded human touches one of these objects then a current will flow through the body of the human. The maximum value of this current will be equal to the short circuit current shown in the table below.

Object	Short circuit current (mA)
Adult human	15
Horse	27
Cow	24
Farm tractor (length 3.7m)	60
Car (length 4.6m)	90
Car (length 5.5 m)	100
Metal wagon (length 5m)	200
Bus (length 8.3m)	300
Bus (length 12m)	500

Table L4.

Short circuit currents for objects resting on ground and exposed to 1 kV/m, 60 Hz field.

Much higher currents will be produced when the objects are exposed to higher fields and the consequences will be the direct danger to life from electrical shock.

5.3. Protective measures from capacitive discharges and contact currents.

- Ensure that all objects in the electric field have equal potentials by grounding them together. This may prove difficult for mobile objects and people.
- Electrically shield objects from the electric fields
- Limit access of people and animals to areas where the field strengths are high.

6. Magnetic field coupling.

In contrast to electric fields, magnetic fields are not perturbed by the presence of organism because living tissues to not contain magnetic materials and their magnetic properties are similar to those of air. The secondary magnetic field produced by the currents induced in the body is very small.

A time varying magnetic field will generate an electric field by induction in accordance to Faraday's Law. Thus a living organism exposed to an ELF magnetic field will also be exposed to an induced magnetic field. The induced electric field causes a current to flow in the conductive body. These currents is known as eddy currents and circulate in a direction that is perpendicular to the direction of the magnetic field.

7. Data on magnetic field coupling.

The amount of experimental and theoretical work carried out on the subject of coupling magnetic fields to living organisms is limited.

8. Biophysical analysis of magnetic field coupling.

Since the magnetic fields induce currents inside the body of the living organism then the effects are the same as those of exposure to the electric fields.

Work carried out on models established the values of the flux densities required to induce current densities of 1 A/m^2 and 1 mA/m^2 which are the threshold values required to stimulate cells and be comparable to endogenous level.

The fields required for the former case are high, they are found only in certain industrial premises.

For the later case, however, the levels are comparable to those found under power transmission lines.

The other effects of magnetic fields are discussed in the next chapter.

9. Protective measures for magnetic field coupling.

There are no practical ways of effective magnetic shielding. It is therefore recommended to restrict or limit entry of personnel to areas of strong magnetic fields or to limit the magnetic fields to which people are exposed to, to safe limits.

10. Review of Cellular studies.

10.1. Growth and metabolism.

Effects on cell division, growth and metabolism may appear at high field strengths (0.1 mT = 80 A/m). Experiments on hamster cells exposed to 3.7 V/m showed no effects on cell survival, growth and mutation rate.

10.2. Membrane effects and activity

The results of in vitro studies suggest that, the time varying ELF electric fields may change the properties of cell membranes and modify cell function. However, no comprehensive and experimentally confirmed theory has yet been found.

11. Review of Animal Studies.

Although it is the interaction of human with ELF fields that is important, scientists are performing many of their experiments on animals and the possible effects on humans are extrapolated.

Although some biological effects were found to be frequency depended, many experiments are performed at 50 and 60 Hz which is the power distribution frequency.

11.1. Neural and neuroendocrine systems

Many of the biological effects observed in animals exposed to ELF fields appear to be associated either directly or indirectly with the nervous system.

The explanations given for this observation are:

a) The nervous system functions are electrochemical processes.

b) The nervous system is fundamentally involved in the interaction of animals with the environment.

The results of many studies are contradictory with claims for both effects are non-effects resulting from ELF exposure.

11.2. Behaviour

Experiments performed at low flux densities showed behavioural alterations, primarily activity changes.

On the other hand experiments with high flux densities have not shown any effects.

This discrepancy may be due to the experimental approaches adopted or there could be a window-type dose response relationship.

11.3. Biological rhythms

ELF fields alter certain circadian timing mechanism in mammals. The health consequences of which have not been established.

11.4. Neurophysiology

Numerous studies have been conducted to determine to what extent an environment containing electric or magnetic fields of 1 - 300 Hz affects the nervous system. The effects reported have not yet confirmed any pathological ones even after prolonged exposure to high-strength (100 KV/m) electric fields and high-intensity magnetic (5mT, 4kA/m) fields.

11.5. Reproduction and development

Although the majority of studies indicate no deleterious effects on mammalian reproduction and development of exposure to ELF electric or magnetic fields, the few studies that report such effects indicate the necessity for further investigation.

11.6. Bone growth and repair.

Reports on this subject are not conclusive in that a study reports that bone fracture repair was retarded in some animals while bone growth as such was not affected. Another study suggests that the rate of healing is affected but the strength is not.

11.7. Cardiovascular Systems.

Early studies reported a decrease in heart rate and cardiac output in dogs exposed to 15 kV/m and an increase in the heart rates of chickens exposed to 80 kV/m.

More recent studies showed no effects on rats exposed to 100 kV/m.

High intensity magnetic fields (2.4 T, 1.9 mA/m, 50Hz) caused heart stimulation in the diastolic phase.

The occasional reports of positive or negative changes in hematological parameters cause confusion and should be carefully evaluated.

In many reports, however there are no statistically significant results and they should be analyzed using more advanced techniques.

11.8. Immunology

In most studies exposures of animals to electric fields does not appear to affect the immune system

On the other hand ELF magnetic fields are reported to strongly influence the immune system response to mitogens and antigens.

11.9. Carcinogenesis and mutogenesis

No effects have been observed, in cellular studies, that night suggest an effect of electric field exposure on mutagenesis and carcinogenesis.

12. Human studies

During the late 1960s and early 1970s studies in the USSR claimed a variety of exposure related symptoms such as headache, poor digestion, cardiovascular changes, loss of sleep, etc. in switchyard workers after prolonged exposure to 50 Hz fields.

These studies sparked off the starting of a considerable number of research projects with the objective of determining the possible effects of these fields.

Most of the studies completed to date do not reach conclusions that are undisputed, because all suffer from certain drawbacks such as the small sample sizes, exact level or duration of exposure, etc.

12.1. Laboratory investigations

Artificially generated electric fields (2 V/m, 10 Hz), alter the human circadian periodicity.

- Brief period exposure to 50 Hz electric fields of 1, 15 or 20 kV/m caused small decrease in reaction time, marginal increase in white cell blood count and slight elevation of norepinephrine level which were probably due to non specific excitation effects.
- Reactions to light and sound was prolonged upon exposure to 50Hz fields.
- 32 persons occupational exposed to electric and magnetic fields produced by 380 kV systems for a period of 20 years showed no difference in multiple physical, hematological, biochemical, hormonal and behavioural tests.
- Evaluation of the threshold of perception of a 50 Hz electric field showed a variation from 0.35 kV/m to 27 kV/m
- Studies involving hematology, serum chemistry, EEG, ECG, blood pressure and body temperature showed no effect when exposed to ELF magnetic fields.
- The visual phenomenon of phospenes has been confirmed. Maximum effects occur at 20 Hz with magnetic flux density of about 5 mT
- Pulsating magnetic fields with repetition rates in the ELF range have been used since the 1970s in stimulating bone union and treating pseudoarthroses, high rate of success has been observed.

Volunteers exposed to 60 Hz electric and magnetic fields, below the perception level, for 8-hour periods showed inconsistently and range within the normal biological variation.

12.2. Epidemiological assessments.

Various epidemiological studies have taken place since the early 1960s mainly in the USSR. There are no uniform results and many conclusions contradict each other. It can also be stated once more that may studies are either incomplete or suffer from drawbacks.

The most recent studies deal with the increasing concern that exposure to ELF magnetic fields may be associated with cancer incidence.

For example the study in Sweden that reported increased cancer rates in children whose homes had magnetic fields greater than 0.3 ìÔ, is considered as invalid because the fields were measured only once.

13. Recommendations.

- Occupational exposure to strong electric fields is generally speaking of intermittent nature and field strengths where spark discharges are prevalent should be avoided. Present knowledge indicates that areas with field strengths below 10 kV/m should not be limited to public access.
- Guidelines on LF magnetic fields are not widely available.
- Exposure to electric and magnetic fields should be considered in the design, the siting and the shielding of ELF sources.
- Possible protective measures to be taken are:
- Shield areas occupied by personnel from electric fields be placing around it conducting surfaces.
- Field strengths decrease with distance from the source.
- Use protective clothing to prevent spark discharges.
- Ground all larger metallic structures which are in the vicinity of high voltage switchgear in order to avoid electric shock to individuals that touch them.
- Follow the conventional electrical safety procedures.
- Provide appropriate education and training to the workforce.
- Measure and record fields regularly as this will enable corrective actions to be taken when necessary.
- Use only trained personnel to perform the measurement procedures.
- Personal meters to asses level and duration of individual exposure to ELF electric and magnetic fields should be developed.
- Further research is needed on the influence of electric and magnetic fields at cellular level.
- Epidemiological studies should be continued and developed to include occupational and residentially exposed people.

14. Exposure Limits.

The basic criterion is to limit the current densities induced in the head and trunk by continuous exposure to 50 or 60 Hz electric and magnetic fields to no more than about 10 mAm^2 . With this guideline and with the support of experimental results and theoretical considerations the following limits apply.

Table L5. Limits of exposure to 50/60 Hz electric and magnetic fields.

Exposure characteristics	Electric field strength kV/m (RMS)		Magnetic flux density mT(RMS)
Occupational			
Whole working day	10		0.5
Short term	30		5
For limbs			25
General public			
Up to 24 h d^{-1}[c]	5		0.1
Few hours per day[4]	10		1

Notes: The duration of exposure to electric fields in the occupational exposure limits, between 10 and 30 kV/m may be calculated from the formula t=80/E where t is the duration in hours per work day and E is the electric field strength in kV/m
The maximum short exposure to magnetic fields in the occupational exposure limits, is 2 hours per day.

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Samico Building
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P.O.Box 8709, 2082 Nicosia, Cyprus

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PRINCIPAL FACTORS EFFECTING A SENIOR MANAGEMENT CULTURE CHANGE FOR TOTAL QUALITY METAMORPHOSIS: A QFD ANALYSIS

Ioannis I. Angeli, Higher Technical Institute
Jeffrey P. Jones, Sabir Bahir, University of Glamorgan

ABSTRACT

Numerous books, reports, methods, tools and training programs have been developed over the past fifteen years addressing the quality revolution. Management commitment, leadership, continued improvement and above all, culture change, are considered the cornerstone for a successful TQM implementation. The reasons that many enterprises fail to implement TQM successfully is that the Chief Executive Officers (CEO) and Senior Management (SM) team are not convinced and do not commit themselves to actively support and participate in quality initiatives.

A three-year joint research study undertaken in Cyprus by the authors focuses on the in-depth investigation of the major Quality parameters that are necessary to bring about change in management culture towards leadership and quality, as well as factors of "how to" succeed and implement it.

This paper, which is an extract from the above research study, concentrates on the top 15 factors required to secure management commitment. These were identified through a survey of more than 200 CEOs, from 15 different countries worldwide.

The detailed scientific analysis was accomplished through the aid of the powerful tool of Quality Function Development (QFD). The common requirements, characteristics and parameters of change management were entered into a full QFD matrix as WHAT'S and HOW'S, leading to a set of prioritized, ranked and important instructions. The investigation and identification of What's and How's, were based on case studies, published material and survey reports of enterprises which have successfully implemented TQM and passed through the process of change.

The investigation provided valuable quality information on the most important common parameters and methods required to change and secure commitment of management to Quality.

INTRODUCTION TO CULTURE CHANGE OF MANAGEMENT TOWARDS TQM

TQM goes far beyond the philosophy and practices of QC and QA. It is a strategy which is concerned with changing the fundamental beliefs and values of a company, harnessing the enthusiasm, participation and commitment of everyone, whether the business is manufacturing or service oriented, towards an overall idea of Quality Leadership [1].

To become a Total Quality organization means changing the company culture by changing its management and its attitudes. This a difficult process. Changing the culture is hard. It takes time and results are not easily measured. Understanding the importance of organizational culture and securing management commitment is critical if TQM is to be successful. A well-functioning business excellence or quality improvement program is impossible without the meaningful support and enlightenment of senior executives.

Today's customers are concerned with how they are dealt with as inviduals and how their needs are met. Thus organizations must focus on achieving a customer-driven service quality. SM must first know what clients want and anticipate their needs, solve their problems and show them opportunities they might not have seen on their own.

This means changing the culture. If this does not happen or if there is a delay in responding to any new economic developments, the company will find itself at a commercial disadvantage.

To reach the stage of excellence, metamorphosis and radical changes are needed in the way CEOs, think, behave and act. Total Quality metamorphosis (TQm) is for those few who wish to become the leading enterprises and remain at the top.

CHANGE MANAGEMENT - RESEARCH

The importance of CEO commitment and culture change are considered to be the cornerstones of any quality initiative. Numerous books, reports and surveys have addressed the above issues. Among others, Dr. S. Black in his PhD [2] thesis identified that the "number one" factor of quality management is "management-led Quality culture".Also Mr.Angeli [3] has identified that the most important parameter influencing progress in Cyprus is CEO culture geared towards quality. This paper is investigating the key factors/driving forces/requirements and parameters (so-called "WHAT'S") for successful CEO culture change towards TQm.

In parallel to identifying **WHATS,** the authors identified all factors addressing the above requirements and parameters, and those factors are reported as **HOW's.** In other words, this study addressed two questions: What are the requirements? and How can these requirements be fulfilled? A more detailed analysis was also incorporated by identifying the 2nd level hows where specific instructions, tools, methodologies were defined on "how to" accomplish "Hows".

Through an international literature search into case studies, surveys, reports journal publications, books, etc, 72 what's were identified. Following that, 165 How's were reported, addressed by 73 2nd level How's. In any published material investigated by the author (more than 160) the reader could identify approximately 10 to 30 what's, how's and 2nd level hows. This research collected, grouped, summarized and listed all academic and practioner views, for presentation. It was always well-understood that there would be a question of reducing those three long lists. They have been reduced, but only up to a point.

This is where our research ran into several problems, such as large questionnaires, codifying, tabulation, software selection, analysis, evaluation, even presentation of charts.

The 72 "what" requirements were grouped under common topics and a questionnaire was formulated by the author and sent to more than 200 CEO's and practitioners from 15 countries worldwide, who were asked to then grade those requirements. The survey results are summarized in Table 1. Further explanation of the top 15 is given to clarify their meaning.

Various methods and techniques have been reported by practitioners dealing with massive volumes of information and parameters that required subsequent tabulation, correlation, analysis, etc. Greg Watson [4] from Xerox used the analysis hierarchy process (AHP) to help to determine what to concentrate on first. Dennis Lawrence [5] used a series of tree diagrams to help SM translate plans into specific actions. The great majority of authors, including Guzy [6] Glyshkorsky E. [7], Mann [8], Kaneko [9] Smith [10], Angeli [11] and many others, used Quality Faction Deployment (QFD) to address similar cases, especially in the service industry and for evaluation of ideas and concepts.

The most important question was whether the QFD matrix could accommodate so many parameters. The questions was partially answered by Michael Hunter [12], who described the Siemens Industrial Automation case. They used QFD in 1990 to help them to identify product feature elements unique to various market segments. That huge QFD matrix or the QFD House of quality, consisted of 40 whats and 103 hows and 4120 relationships. It was one of the largest in the world. Having in mind Hunter's words, "Don't let the simplicity of QFD scare you away", it was decided that QFD would be used in this research to help identify the vital few. Figure 1 [13] shows the original QFD house of culture change matrix with thousands of cells (46% full) developed by the author for this research. There were 33000 relationships to be analyzed if every cell was to be addressed.

The 72 whats and 165 hows were entered into a very specially designed QFD software. The results of the inter-

CODE	RNK	REQUIREMENTS AND KEY SUCCESS FACTORS FOR CEO CULTURE CHANGE	AVG X	RGE R	MIN. GRD	MAX. GRD	
W25	1	Acceptance that the customer is paramount & understanding its meaning	91.791	60	50	100	
W141	2	Quality leadership	87.9231	35	65	100	
W35	3	Company's perception of quality	87.5	40	60	100	
W127	4	Strong top down commitment	87.3016	50	50	100	
W70	5	Adequate SM support	86.7647	40	60	100	
W145	6	Support of the board of directors	86.25	55	45	100	
W80	7	SM consistency, accountability & responsibility	86.25	60	40	100	
W126	8	Ownership and internalized SM commitment	86.2308	100	0	100	
W2	9	Vision where company is going (goals, values, ethics)	85.493	60	40	100	
W75	10	Acceptance of change	85.1667	40	60	100	
W4	11	Clear/vision led strategic & holistic approach to change	83.8235	50	50	100	
W180	12	Corporate team spirit (teamwork)	83.6765	50	50	100	
W370	13	SM must find time for changing culture	83.4483	75	25	100	**Table 1**
W125	14	Form an action plan with actionable first steps	82.4242	50	50	100	**Summary**
W165	15	Need to motivate change and people	82.4242	50	50	100	**Survey**
W365	16	Continous monitoring & assessment of improvements auditing, feedback	82.4138	80	20	100	**Results**
W315	17	Effective decision making system	82.0313	80	20	100	
W350	18	Develop a strong culture	79.8333	80	20	100	
W155	19	Establish a top-level quality improvement committee	79.7059	95	5	100	
W150	20	Process insider denominator, facilitator,	79.3548	95	5	100	
W280	21	Identify & communicate improvement information	79.3548	50	50	100	
W220	22	Influence or convince management & gain enthusiasm	79.25	100	0	100	
W55	23	Attention to stakeholder interests (participation)	78.125	95	5	100	
W140	24	Management leadership role - style- values	78.0469	70	30	100	
W50	25	Synergy between quality & participation	78	60	40	100	
W335	26	Increase managers effectiveness as change agents	77.1212	65	35	100	
W295	27	Focus on processes, systems, plans improvements	77.0588	60	40	100	
W380	28	Managers create a safe environment to take the risks of change	76.7647	65	35	100	
W320	29	Strategic planning	76.6129	70	30	100	
W345	30	Policy deployment: planning, implementation., reviewing	76.6	65	35	100	
W200	31	Managers' perception on quality factors	76.5	45	50	95	
W10	32	Understanding the change its meaning/managing implementation	76.3793	95	5	100	
W65	33	Building learning & development capabilities	76.1765	65	35	100	
W6	34	Effective & capable board members and competent directors	76.0938	90	10	100	
W85	35	Cooperation among managers	76	90	10	100	
W325	36	Increase managers effectiveness as change agents	75.8929	85	15	100	
W210	37	Gain the benefits of empowered employees	75.7813	65	35	100	
W100	38	Market competition - competitors - pressures	75.4286	72	25	100	
W290	39	Recognition & celebration of successes	74.6667	60	40	100	
W185	40	Quality overall performance information	74.5313	60	40	100	
W115	41	CEO problem (s) recognition	73.9394	50	50	100	
W20	42	Management skills, techniques, of practices, style, traits	73.3824	55	40	95	
W3	43	Common vision definition	72.2581	100	0	100	
W105	44	SM assessment / system (performance appraisal)	71.8182	90	5	95	
W15	45	Efficient utilization of resources	70.8333	90	10	100	
W1	46	Board room vision	70.6452	95	5	100	
W160	47	Anticipate resistance to change	69.6774	80	20	100	
W215	48	Manager gain credibility by developing reputation for performance	68.6667	85	10	95	
W330	49	Managers create a safe environment to take the risks of change	68.5938	65	25	90	
W340	50	Learn and apply the system of profound knowledge	67.8788	80	20	100	
W60	51	Emphasis on social humanistic dimensions & quality of life issues	66.8571	90	10	100	
W190	52	Adequate managerial & organizational infrastructure (business structure)	66.8333	85	10	95	
W90	53	Joint union-driven quality initiatives	66.5152	100	0	100	
W230	54	Cooperation between the quality profession and managers	66.0345	100	0	100	
W170	55	Management of transition and stages	64.1667	75	25	100	
W305	56	Benchmarking world-wide	63.5	80	20	100	
W30	57	Assessment of future threats and opportunities	63.4483	95	5	100	
W310	58	Believe in the unexpected/ mastering paradox unpredictability	63.1667	95	5	100	
W135	59	Highly resilient people	62.7778	90	10	100	
W300	60	Use consultants/guru to support SM	57.5	80	10	90	
W203	61	Maintain managers health by managing stress positively	55.3125	100	0	100	
W95	62	Changes in regulations, laws, policies partnership	54.8214	95	5	100	
W260	63	SM characteristics (age, attitudes, gender, etc.)	54.6429	100	0	100	
W375	64	Changes applicability to the type & size of organization	54.5455	90	10	100	
W225	65	Institutionalize total quality	52.1154	100	0	100	
W235	66	QM has to be given academic status	52.0588	100	0	100	
W45	67	Crisis and urgency as an agent for change	51.4655	100	0	100	
W335	68	Increase managers effectiveness as change agents	51.2069	90	0	90	
W240	69	Cooperation of companies and government	49.3333	90	5	95	
W250	70	Managers' formal qualifications	47.4138	90	0	90	
W360	71	Budget cutting threat	44.2424	95	0	95	
W110	72	Political systems changes & liberalization	40.303	90	0	90	

national survey (Average value X, Table 1) were entered as importance numbers into the matrix. Several exercises were executed using modified QFD matrices incorporating the opinions/evaluations of academics, practitioners and the author. After a very laborious process and experimentation with results, the QFD phase I matrix was formulated. From that the top 15 "whats" requirements were evaluated as well as the top 15 most important "hows" addressing the great majority of "whats". Forty-six How's from the first matrix were then selected and became whats in phase II. Those 46 whats were then addressed by the 73, 2nd-level hows. The same procedure as before was followed, but with a smaller matrix. The second analysis revealed to the top 15 "2nd level hows" which can give answers or enhance the implementation of the great majority of hows.

Due to limitation of space and to the large size of the original chart (90 cm X 180 cm) only the first top 15 whats and the 69 hows with the strongest relation with whats, were selected and analyzed in this paper and are shown in Figure 2 [13]. For publishing reasons the chart has been reduced to 30% of the original size. This is the first time were QFD technique was used on so large a scale for nonquantitative and conceptual data.

Much useful and valuable information can be extracted from Figure 2, what will help guide senior managers to can change their culture and commit themselves to quality leadership.

THE VITAL FEW

In the following paragraphs the top 15 key success parameters and requirements (what's) are presented, as well as the top 15 factors addressing the majority of the above requirements. The selection for what's was based on their ranking (importance number) in the international survey, and the selection of Hows was based on the "How" importance raw number (The higher the better) of the top 15 QFD matrix (Figure 2) and original QFD matrix (figure 1). Similarly the selection of the top 15 2nd level hows was based on the "how" importance number.

The top 15 key success parameters for CEO culture change towards quality (whats) in rank order

Recognizing that the customer is paramount and appreciating his value to the company
Quality leadership
Company's perception of quality
Strong top down commitment
Adequate senior management support
SM consistency, accountability and responsibility
Ownership and internalized SM commitment
Vision of where company is going (goals, values, ethics)
Acceptance of change
Clear vision-led strategic & holistic approach to change
Corporate team spirit (teamwork)
SM must find time for changing culture
Form an action plan with actionable first steps
Continuous monitoring, assessment of improvements, auditing, feedback

Effective decision-making system

The top 15 "hows" factors in rank order addressing key success parameters (whats)

High level of communication and similar views
Delivery of the appropriate training to management
Good operational and strategic plan
Adopt continuous improvement of Quality
Communicated goals and understood by everyone
Leaders with adaptable behaviors and culture leadership skills
Reward and recognition system

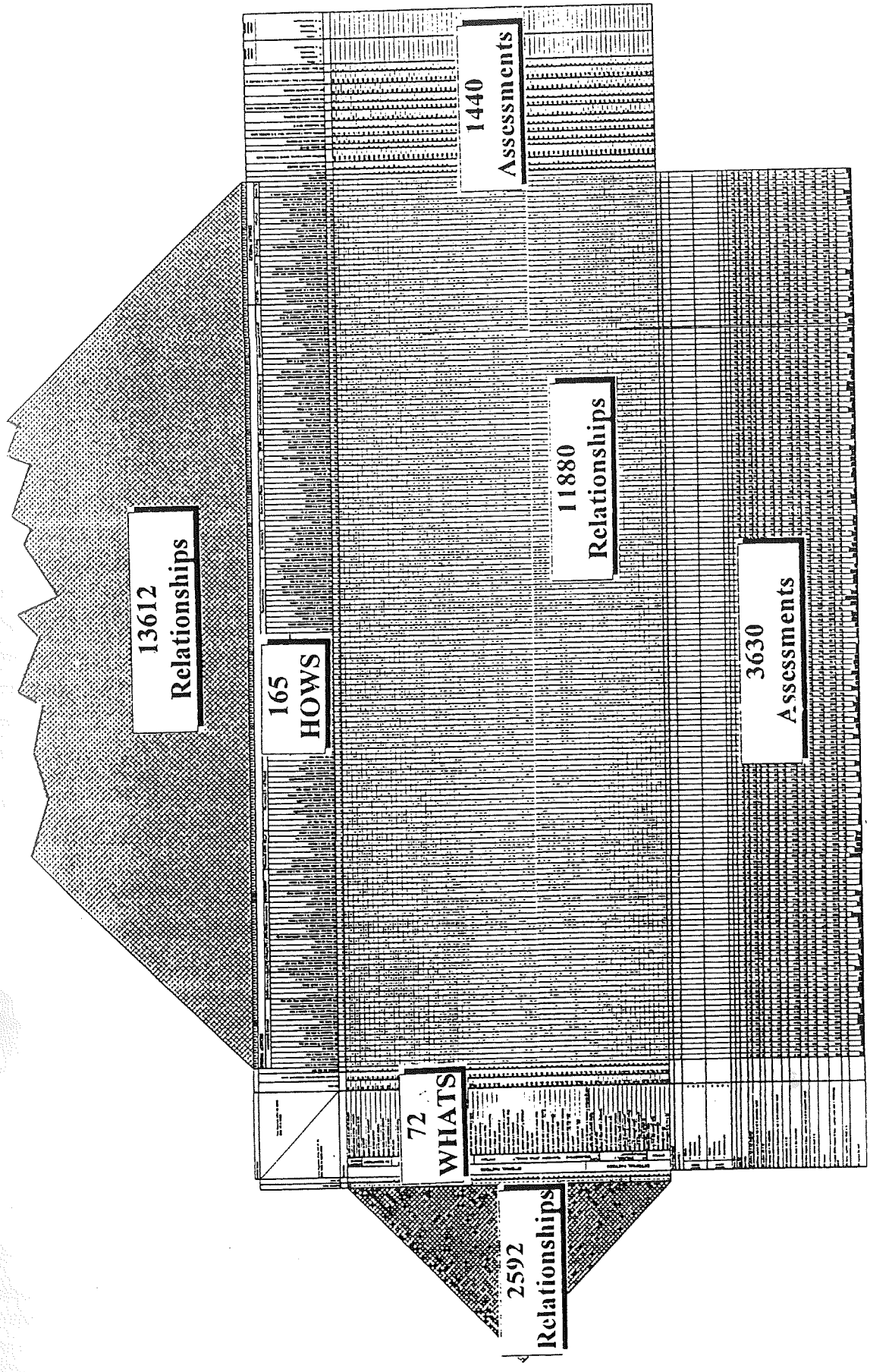

Figure 1: Original Research Modified QFD matrix

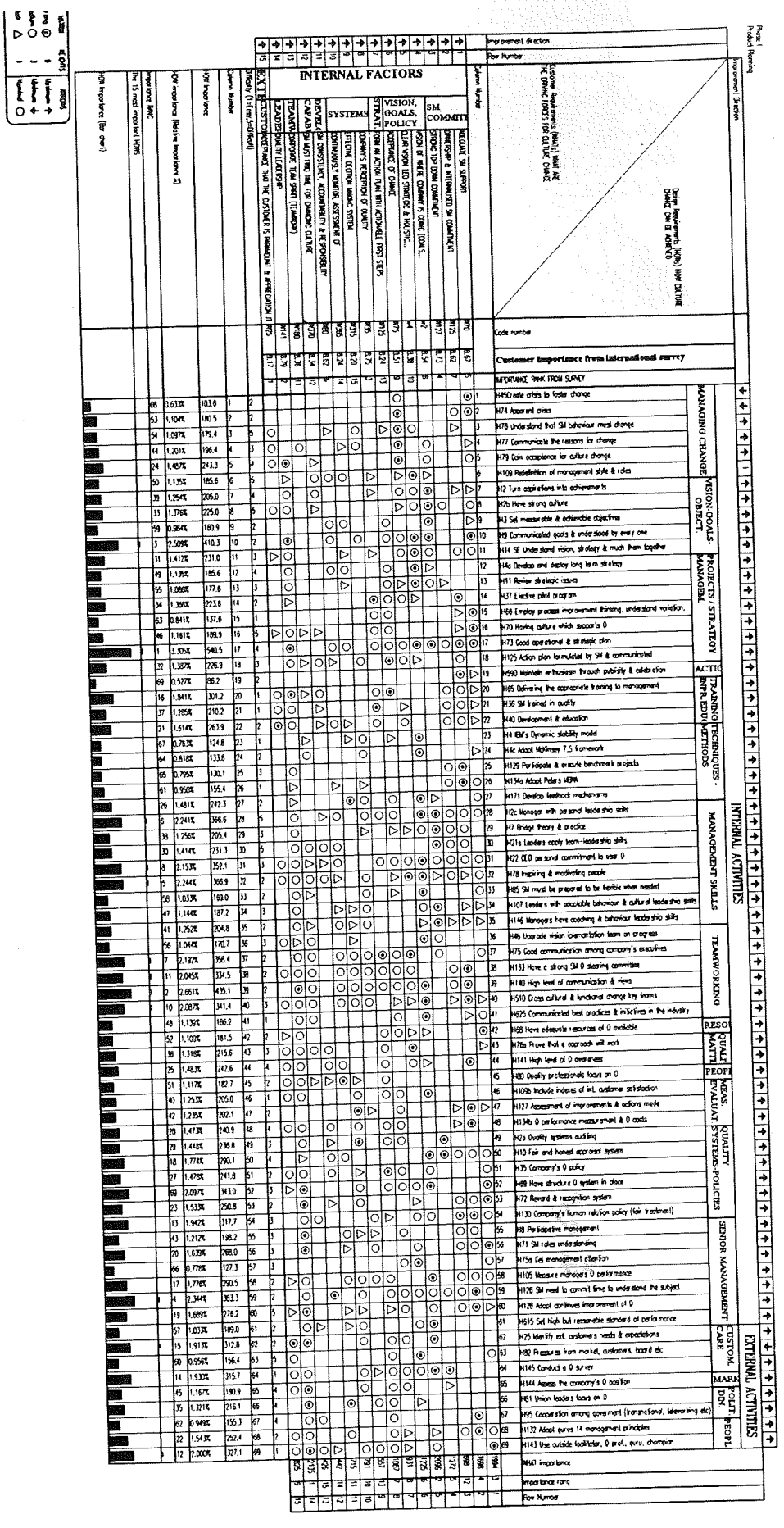

Figure 2: The top 15 whats QFD matrix

Information sharing, two-way communication teams
Inspiring and motivating people
Company's human relation policy
Use outside faciliator, a professional, guru, champion
Have a strong SM Quality steering committee
Conduct a Quality survey
Have a small Quality directorate of internal consultants
Gain acceptance for culture change

The top 15 "2nd level hows" in rank order demonstrating "how to" succeed hows.

Adopt 5Ps behaviours: positive, pro-active, participative, productive, pioneering
Participation in development of devices such as surveys, sensing groups, etc.
Managers' competency
Provide teams with clear directions and choices
Define what change is required
Build trust and inspire team work
SM characteristics of a superior leader
SM meetings devoted to quality issues
Company mission and vision, health and safety, in-house courses
Personnel analysis (company's human resources)
Written statement to classify/describe future and changes
Employee satisfaction goals
Facilitate team in creating its own action plan and support
Use of quality audit checklists and orientation questionnaires
Leadership styles: defective, participating, delegating

CONCLUSIONS

Starting from the point where other researchers stoped (Black, K., Angeli I. and others), when they were investigating the key success factors for corporate and nation culture change, this, research has attempted to look more deeply into CEO culture change. The great majority of previous surveys reported that the managers are the key factor in any change situation.

If the manager understand, is convinced or is forced to adopt the new philosophies of quality leadership, there is an opportunity to change not only his way of thinking but also his subordinates, using all or some of the parameters and how's identified in this research. The rest is a matter of time, some will follow the easy way and some the hard way. Using the large list of factors, each manager can identify, adopt and use all or some of those he or she believes are most suitable for the organization and those best or most applicable to the existing culture and attitudes.

"There is no quick fix, easy solution, universal panacea, quality management tool or technique, system or assessment method which will provide all the answers; there are no ready-made packages which can be plugged in and will guarantee success" [14]. It is an extremely arduous process. The planning horizon to put the TQm basics into place greatly depends on management commitment. And this is the case of culture adaptation or change.

Authors note: The huge QFD matrix, the rest of the parameters and the list of references (165) are not presented due to limitation of space. If there is a genuine interest in receiving a copy of the additional information you may write to Mr Angeli directly. He will be pleased to share his knowledge with you after the submission of this PhD thesis in September 1997.

REFERENCES

1. Atkinson, Ph., 1990. Creating culture change: The key to successful TQM. IFS publications, (UK).

2. Black, S., 1994. Measuring the critical factors of TQM. PhD dissertation, University of Bradford, (U.K).

3. Angeli, I., 1993. Evaluation the status of TQM in Cyprus manufacturing Industry. MPhil dissertation, University of Glamorgan, (U.K).

4. Watson, G., 1994. The deciding factor. The Benchmark News, pp. 3-6. (USA).

5. Lawrence, St. D., and Stinnect B. 1994. Powerful planning with simple techniques. Quality Progress Journal, ASQC, July, pp. 57-64, (USA).

6. Guzy G., Marcia C., 1992. The leader as customer: QFD -designed education. Transaction of the ASQC quality congress - Nashville, ASQC pp. 465-471, (USA).

7. GlushKorksy, A Eli, F. A. Rady, A. Hershkovits and D. Sipper, 1995. Avoid a flop: Use QFD with questionnaires. Journal of Quality Progress, ASQC, Vol.28, No.6, pp 57-62, (USA).

8. Mann, A. Cr. and Helbleib, 1992. The application of QFD to a national security issue (a case study), ASQC Quality Congress Transactions - Nashville, pp. 500-512.

9. Kaneko, Noriharu, 1991. QFD implementation in the service industry. Proceedings of the 45th Annual Quality Congress, (USA).

10. Smith, T., and Angeli, I. 1995. The use of QFD to help to adopt a TQ Strategy, The TQM Journal IFS publications, vol.6, No.1, pp. 35-44, (U.K).

11. Angeli, I., 1992 ISO 9000 and the philosophies of the quality gurus: A QFD case. Proceedings of the 9th International conference of the Israel Society for QA , (Israel).

12. Hunter, R. Michael and D.R. Van Landingham 1994. Listening to the customer using QFD, Quality Progress Journal, ASQC, pp. 55-59, (USA).

13. Angeli, I. Jones J. 1996. Securing management commitment to quality: A QFD analysis, proceedings of the 11th International conference of the Israel society for Q.A. pp. 356-364, (Israel).

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INTEGRATED APPROACHES TO ENERGY EFFICIENT BUILDING DESIGN

Dr Despina Serghides AADipl., RIBAII, AAGrad., PhD.
ISES - Cyprus President, Senior Lecturer Department of Civil Engineering, HTI.

ABSTRACT

No one can question the increasing importance of ecology in the world today, and quite rightly so. Securing a high standard of living and maintaining a healthy environment are considered primary parameters in development. Architecture, as a science which concerns itself with man and his surroundings, cannot but show an interest in the relationship between man and the environment, as well as ways of approaching this association. The convergence of different factors, applied in the past few years in bioclimatic architecture to exploit climactic and topographic conditions, aiming at a permanent energy efficiency in buildings, constitutes an additional challenge to the architect.

This paper will examine the bioclimatic design as a climatically interactive building design, which integrates the scope to use the location and the regulatory systems inherent in architecture, through the choice of orientation, form , fabric and the use of natural resources of energy to achieve comfortable interior conditions for energy efficiency.

1. INTRODUCTION

There is no doubt the design challenge is highlighted and all the more complex when the designer uses the architectural design itself to utilize natural renewable energy resources rather than the use of auxiliary energy, for the provision of indoor comfort. Nevertheless, the issue of bioclimatic design should not be viewed as an additional aspect isolated from the architectural process. It would be wrong for architects to permit special technicians to design and calculate installations for interior comfort and restrict their own task in camouflaging the mechanical equipment. Wrong is, also, the tendency to apply passive heating or cooling systems after the buildings have been incorrectly conceived. Adopting such strategies ignores the fact that the environmental functions of a building itself must be considered as a climatically interactive design tested dynamically in an integrated approach.

After a retrospective study of the traditional approach and comparison with the contemporary one, the paper presents the results of the thermal analysis carried out with the aid of microcomputer programs for heating and cooling in the Mediterranean houses, and shows the signigicance of the interactive and integrated approach.

2. TRADITIONAL INTEGRAL APPROACH AND CONTINUITY

Traditional architecture has evolved over many years as a result of an integrated design approach based on a trial and error process transmitted through generations. It was gradually corrected and adapted to meet the needs of the people and the conditions of the environment. Therefore, buildings resulted as the product of a diversity of influences, requirements, demands and constraints; be they topographic, climactic, cultural, social constructional, functional, stylistic or financial. They reflected the complex relationship amongst all influencing forces acting together in a variety of architectural types but always in harmony with the natural laws of each locality.

3. DISRUPTION OF CONTINUITY AND THE INTEGRAL APPROACH

The mass media, the faster pace of life, the abrupt oversweeping modern movement, the irrational tourist development in many countries, all inflicted sudden changes. These could not be accommodated in the determining factors of the core traditional model which requires extensive temporal inertia until the trial and error process produces new normative patterns. Rapid urbanization and the inefficient use of building services technology has had catastrophic consequences on many countries ecology, culture and tradition. In domestic buildings there is a trend towards greater standards of comfort which has led to the increasing adoption of air conditioning systems and has given the upper hand to mechanical installations for the indoor comfort in the buildings.

4. FROM TRADITIONAL TO CONTEMPORARY APPROACH

It is evident that the task of the modern architect is considerably more complicated than that of indigenous builders. The demands of modern life introduced new factors and considerations into the design of buildings beyond the basic traditional ones. Nevertheless,

as technology advances and life becomes more demanding, the judicious and optimal organization of complex variables involving technical, social, utilitarian and cultural aspects still converge on creating comfort and convenience to the user. The tools, materials and techniques available to the modern architect are more than enough to enable him to achieve efficient utilization of energy in contemporary architecture, without attributing priority to machines.

5. BACKGROUND TO INTEGRATED APPROACH

In order to achieve energy efficient buildings in an integrated mode, certain background studies are necessary such as analysis of the prevailing climactic conditions to assess how energy demands for heating and cooling arise in buildings and to evaluate the free energy systems available to contribute to these requirements. Furthermore an evaluation of traditional, existing and new built houses, is necessary to identify deficiencies in the regulatory systems inherent in the built form that result in heating and cooling demands. In this respect and beyond the specific architectural requirements of the building, other influencing factors must be reviewed such as:

a) Building regulations and planning legislation

b) Architectural trends

c) Building construction methods and techniques

d) Energy sources and usage

e) Comfort standards

6. ENERGY EFFICIENT MEDITERRANEAN BUILDINGS

The above aspects were considered for designing energy efficient buildings in the Mediterranean region. The Mediterranean climate, although defined as mostly mild, can have surprisingly cold winters and extremely hot summers and therefore requires both heating and cooling to varying degrees. The requirements for cooling are often predominant.

For the thermal analysis initially simplified thermal calculations were carried out by using "Method 5000", a well established method adopted by the commission of the European Community's handbook. Those were followed by detailed hourly simulations of selected variants using dynamic simulation model "Seri-Res". Finally thermal analysis programs "Quick" and "Agrelek" are used to study the effect of the occupants' interaction with the building. The main tested variables are:

a) Shape

b) Mass

c) Fenestration

d) Insulation

e) Occupants Interaction with the Building

The effect of the most important parameters of these variables, on the thermal response of the building was assessed during both heating and cooling modes in an interactive and dynamic approach. Through analysis and evaluation of alternative design options, hypothetical data and comparison of the performance of the parameters with each other, the study has identified and quantified the principal factors for energy efficiency in the Mediterranean buildings.

7. THE RESULTS

The results explicitly indicate that a change of one parameter can frequently be compensated for by changes in the other, thus emphasizing the vital importance of an integrated design approach. The main findings of the results of the five variables aforesaid are outlined in a conclusive form below.

a) Shape

The varied shape design of the buildings was considered in combination with other variables such as:

- Orientation of fenestration

- Addition of mass internally and externally

- Introduction of insulation

Pertaining to the tests on shape it was found that simple compact shapes are more energy efficient than complex ones. However, it is noted that variations or introduction of other parameters on complex shapes may also render them equally or more energy efficient than simple ones. Insulation on the envelope can act as a regulator of complex buildings.

The east-west orientation of the long axis of the building with more surface exposed to the south, improves the performance for energy efficiency. Regarding mass, addition of it externally increases heating and cooling load on all shape variations, whereas addition of internal mass decreases both.

Addition of internal mass facing south, in combination with large areas of south glazing, reduce energy load. It is obvious from the shape study that the development of the building variables in various shapes, into a dynamic and effective pattern of design choices and constraints, necessitates thermal studies for each single building with its own geometry configuration and particularities.

b) Mass

The aspects relating to mass are of particular significance for the Mediterranean region due to the large diurnal fluctuations and the potential possessed by mass for the large solar contribution in winter and cooling in summer. This implies that heat admitted during the day in winter could be stored for use during the evening hours and in the summer could be dissipated into the cool night. In the study the addition of mass has been examined in relation to be building shape and it was found that addition of internal mass incurs energy conservation of varied extent according to the thermal behavior of each building.

On the contrary, addition of external mass leads to higher energy consumption. Moreover from the studies it was found that in order to determine the full extent of the effect of mass on the thermal behavior of the building, interdependent analysis is necessary concerning parameters such as:

- Collective and storage characteristics of the materials of the surface finishing

- Location, quantity, distribution and surface of mass

- Orientation of internal surfaces

- Diurnal and spatial temperature swings

- Combination of window sizing and extent of thermal mass

c) Fenestration

The thermal analysis reinforced the significance of the examination of fenestration in conjunction with the entire building as glazing is thermally a very sensitive, complex, many sided component. In the series of studies on Orientation, Shading, Ventilation, Infiltration and Glazing Type the following were observed:

- The fenestration orientation is a significant determining factor, for thermal gains in winter, as well as summer overheating in Mediterranean buildings. It was found that for the optimal orientation of fenestration, detailed studies are needed for each and every building since this variable is closely interrelated with many other building parameters such as the size and location of openings of the building facade. These in relation with the internal layout, the depth of space and the opaque building elements affect not only the direct insolation but also its conversion to thermal energy and its redistribution inside the building.

- Permanent shading such as overhangs and side walls must be designed in terms of orientation and dimensions for solar gains in winter and at the same time reductions of overheating in the summer. Movable shading devices offer flexibility and intrinsically have the potential for controlled operation. However, they are subject to user intervention, as indeed is ventilation which constitutes an effective measure in

minimizing air conditioning energy load.

- The type of glazing although an effective means of controlling heat losses in winter and overheating in the summer, financially depends on many other parameters of fenestration.

d) Insulation

The insulation studies showed that the addition of insulation could act as a regulator for energy conservation on a geometrically complex shape building. However, the economic assessment of insulation should be viewed in conjunction with each building configuration.

Furthermore, the studies indicated that extensive sensitivity studies are needed to define a pattern of the effectiveness of the insulation thickness although the tests on thickness imply diminishing returns as the insulation thickness increases.

Comparison of insulation on reference and improved design suggests that combination of other design measures of the improved design increases the effectiveness of insulation. External insulation is the most effective for the Mediterranean climate. Yet, the insulation positioning depends also on the type of building and air conditioning used.

The application of insulation on the roof is the most cost effective energy saving design measure. Extending insulation on the walls and floor reduces energy, but at an additional cost.

e) The occupants

The research has found that it is possible to achieve comfort conditions, for the Mediterranean climate, by many different combinations of optimized and effective variables, in the building design such as compact shape and the optimization of insulation, mass and fenestration designs.

However, peoples' responses are a very important consideration in the creation of indoor comfort conditions, but the occupants' designed comfort level is not a manipulable input factor. Moreover, a house is not merely a container in which people act like robots and are placed to receive its thermal effects.

There is a dynamic dialogue between building controls and building use. Furthermore, for the Mediterranean climate, it is necessary that some of the employed passive systems must be activated by the users in order to be effective. Therefore, in the study the relative thermal effects of the user interactive parameters in various combinations in computer simulations were considered.

From the analysis of the results, it was found that the human element is instrumental in changing some of the assumed building characteristics by such simple acts as opening or closing doors, windows and shutters. It was also found that the effects of the behavior of the building and the users must be considered interdependently as it is the combined effect that is important.

8.CONCLUSIONS

It is concluded that optimization of the regulatory building systems, in order to achieve its fine tuning and become a successful climactic moderator, evaluation of the building performance, and ultimately analysis of cost effectiveness, necessitates detailed and at the same time robust, dynamic and interactive design approach. This is nowadays possible with the use of computer analogues, a well established practice, but at the same time on continuous development. No doubt the potential of bioclimatic design is dependent on a multi-disciplinary design approach. However, the thought that buildings could be permanent energy savers, demands building designers to consider carefully the practical options available to them in an integrated mode.

9. REFERENCES

1. Serghides Despina "Zero Energy for the Cyprus House" Ph.D 1993 U.K.

2. Serghides Despina "The Wisdom of Tradition: Lessons from Cyprus" Sun World Vol. 18, No.1 March 1994.

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MODERN SCIENCE IN THE BIBLE

Dr H.M. MORRIS B.S., M.S., Ph.D.
Head of the Civil Engineering Department
Virginia Polytechnic Institute

ONE OF THE MOST arresting evidences of the inspiration of the Bible is the great number of scientific truths that have lain hidden within its pages for thirty centuries or more, only to be discovered by man's enterprise within the last few centuries or even years. Let us look at a few of these.

Consider the field of astronomy. For thousands of years, many wise men have busied themselves with counting the stars and constellations. Before the invention of the telescope in the seventeenth century, the number of the stars was regarded as practically determined. The great Ptolemy gave the number as 1,056. Tycho Brahe cataloged 777 and Kepler counted 1,005. This number has since been tremendously increased, of course, and the end is not yet even remotely in view. It is now known that there are well over 100 billions of stars in our own galaxy, with probably billions of other galaxies like our own. Most astronomers now agree that it is not humanly possible to count all the stars. This would not have been admitted by scientists a few centuries ago. But the Bible makes the assertion over and over again. One such instance is in Jeremiah 33:22. "The host of heaven cannot be numbered".

As another example, look at Job 26:7, "He ... hangeth the earth upon nothing". That sounds amazingly like twentieth century science! Even the existence of the hypothetical space substance called ether is now believed by most physicists and astronomers to have been disproved. The attraction of gravity is invoked to account for the earth's affinity to the sun, but that explains nothing. No one knows what gravity is or why it is. It is merely a term invented to explain certain observed phenomena. Truly, there is nothing that modern science can add to or take away from the age-old statement that God has hung the earth upon nothing. Or consider Isaiah 40:22, where speaking of God, the prophet says: "It is he who sitteth upon the circle of the earth". The word translated "circle" is the Hebrew khug, a more exact connotation of which is "sphericity" or "roundness".

Psalm 19 was long a source of amusement to Bible critics. In speaking of the sun, the psalmist says: "His going forth is from the end of the heaven, and his circuit unto the ends of it: and there is nothing hid from the heat thereof". It was claimed that the writer of this verse obviously believed in the ancient notion of the sun's revolving about the earth.

This charge is most unjust, since we still use words and phrases of the same sort, simply because from our natural viewpoint the sun does rise in the morning, move across the sky, and set in the evening. The whole science of nautical and engineering astronomy is based on the assumption, made purely for convenience, that the earth is the center of a great celestial sphere, moving along the surface of which in ordered paths are the sun, moon, planets and stars. And as far as any practical usage is concerned, this is so. On this assumption, courses can be plotted, positions determined, and scores of other applications made.

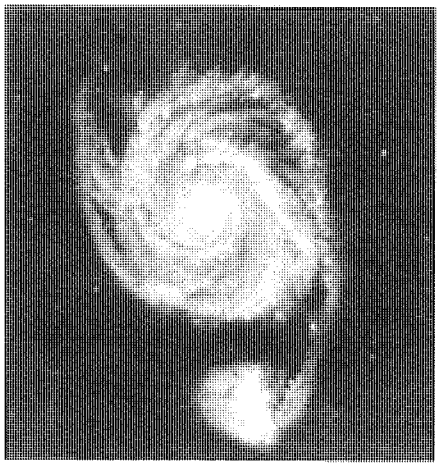
But the words of the psalmist may have a deeper, more truly scientific meaning than that. It is now believed by the leading astronomers that the sun, with the entire solar system, actually does move through space at the tremendous speed of 600,000 miles per hour in such a gigantic orbit that it requires over two million centuries to complete it. Furthermore, it is probable that our galaxy is also moving with respect to other galaxies. The sun's circuit is from

one end of the heavens to the other! Who can accuse the Holy Spirit of ignorance of modern astronomy ?

It is glorious to realize that the great Astronomer and Mathematician who created the heavens, setting all the stars and universes of stars in their appointed courses, and who, according to Psalm 147, calleth them all by their names, is the same One who calls you and me to eternal life in Jesus Christ!

But let us look into the science of meteorology for a moment. The water cycle, whereby water is precipitated as rain or snow, then drained off by the river system into the ocean, whence it is raised by evaporation back into the skies and carried by the wind back to the land to be again precipitated, is a fundamental fact of this comparatively new field of science. Yet this fact was strikingly set forth in the Bible ages before men discovered it. Furthemore, it is now well known that the major wind currents of the world follow well defined circuits. These great wind circuits are largely responsible for all the great ocean currents as well as the great air currents of the world. But this great truth is a matter of comparatively recent discovery. Now read Ecclesiastes 1:6-7, set down by King Solomon three thousand years ago: "The wind goeth toward the south, and turneth about unto the north; it whirleth about continually, and the wind returneth again according to his circuits. All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come, thither they return again." No wonder we speak of the wisdom of Solomon! But isn't it pertinent to ask how he happened to know these things when no one else knew them until thousands of years later?

Also consider the words of Elihu in Job 36:27-29 (ASV, margin): "For he draweth up the drops of water, which distill in rain from the vapor thereof, which the skies pour down and drop upon man abundantly. Yea, can any understand the spreadings of the clouds, the thunderings of his pavilion?" This passage is a most excellent, concise summary of those phases of the hydrologic cycle involving the very marvelous physical



processes of evaporation, condensation, and precipitation.

There is very much for science yet to learn concerning the details of the processes of the water cycle. Each phase of the cycle is absolutely necessary for life to exist on the earth, and offers abundant testimony to its origin at the hands of an infinitely wise beneficent Creator. There are many more references in Scripture to various phases of the sciences of hydrology and meteorology, all remarkably in accord with the most up-to-date studies in these fields.

It is very significant that the medical and sanitary laws and regulations of Moses were very far in advance of the times. To see this, one need only compare the customs and beliefs of the ancient Egyptians and Babylonians, for instance with those of the Hebrews as given to them in the books of Moses. For example, in Leviticus 11 is found a list of animals, fishes, birds, and insects that the Israelites could regard as clean and fit to eat. The criterion of both chewing the cud and parting the hoof was set as a guide to the clean animals. We still go by the same role, except that we eat also the pig, the rabbit, and the hare, which were prohibited to the Jews by this rule. It is now known, however, that these latter animals are easily subject to parasitic infection and are safe only if they have been cleanly fed and have been well cooked before eating. The birds and fish the Israelites were permitted to eat are the same as those now known to modern medical knowledge to be the safest and best. The only insects allowed for food were certain locusts, beetles and grasshoppers, which are now known to be clean feeders, and safe for human consumption. They are still eaten in large quantities in other parts of the world and are evidently quite satisfactory as food.

In Deuteronomy 14:21, Moses forbade the Jews to eat the flesh of any animal that had died a natural dealth, in spite of the fact that they lived in desert regions and their flocks were very essential sources of food. This is still regarded as such good advice that similar laws are in force in most civilized countries today.

The subject of water supply and sewage disposal are of great interest and import to both bacteriologists and civil engineers, as well as to the general public. It was not until the last century that the significance of a clean and sanitary water supply in the prevention of disease was recognized. But Moses seemed to understand something of modern bacteriology, because he forbade the drinking of water from small or stagnant pools, or from water that had been contaminated by coming in contact with animals or meat. (See Lev. 11:29-36). In Deuteronomy 23:12-14, directions were given for the disposal of sanitary sewage by burial. All of these sanitary regulations, as well as those concerning the personal cleanliness of the body, were far in advance of the practices in even the so-called civilized countries of the world until within the past hundred years. This is true also of the prescribed segregation and treatment of such diseases as leprosy.

Not only were the scientific and medical laws of Moses far ahead of the times, but so were the civil laws. It is well known that the laws of Moses form the basis of the law systems of all the great democratic nations of the world today. Although it is true that the early Babylonians and Hittites had codes of laws that were similar in some respects to those of Moses, it is also true that they were not nearly as logical, just or complete, as those in the Pentateuch. Even more important, the Hebrew law was unique in that it centered everything else in the worship and serving of one God, a concept utterly foreign to the Babylonians and Hittites of that day.

The great truth revealed in Leviticus 17:11 and a number of other Scriptures concerning the preeminent importance of the blood in the biological mechanism, has only been comprehended with any adequacy in recent years: "For the life of the flesh is in the blood"

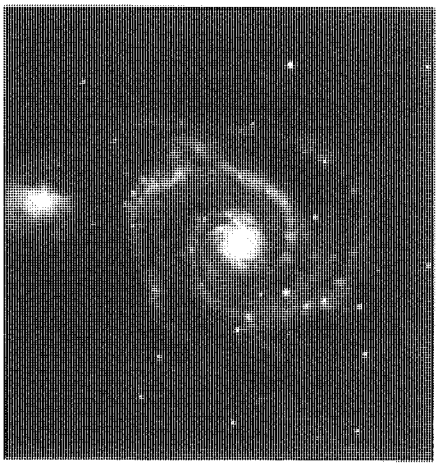
Continuance of life depends upon the continued supply of oxygen, water and food to the cells of all parts of the body. This absolutely necessary function is accomplished in a marvelous manner by the blood as it circulates constantly throughout the body, year after year. The function of blood in combating disease-producing organisms and in repairing injured tissues is one of the most significant discoveries of modern medical science, and the use of blood transfusions as one of the most beneficial treatments for nearly every kind of disease further testifies to the supremacy of the blood in the life of the flesh.

The Word of God was scientifically accurate in this great biological truth thousands of years before man discovered and elaborated it. Yet it was given primarily to teach an even greater spiritual truth-the necessity of the shedding of blood in sacrifice for the remission of sins. The blood, which is the channel of life, becomes also the carrier of disease and infection through the body when they gain the upper hand in the system. Physical life symbolizes spiritual life, and physical death symbolizes spiritual death. Physical disease and injury symbolize the spiritual disease of sin.

As the infection of sin spreads throughout the soul, it will ultimately produce eternal spiritual death. If spiritual life is to be produced and maintained, new life must be introduced from without, life untainted with sin and containing the power to combat the ravages of sin in the spiritually dying soul. In figure, a transfusion of blood is essential, and it must be from a qualified donor whose blood possesses the purity and efficacy required for the salvation of the spiritually dying soul.

This is the merest glimpse of the depths of spiritual (and even biological) meaning in the biblical doctrine of substitutionary sacrifice. "Without shedding of blood is no forgiveness" (Heb. 9:22, margin). This was the symbolism of the animal sacrifices of the Mosaic law. It finds its ultimate and universal culmination in sacrificial death of the Son of God for the sins of the world. Jesus said: "This is my blood of the covenant, which is poured out for many for the forgivenses of sins" (Matt. 26:28, RSV).

By virtue of Jesus' atoning death, each one who receives by faith His life-poured



out unto dealth, but raised up again by the power of God-receives forgiveness and cleansing of all sin, and in fact receives Christ Himself. All this is symbolized by the shed blood, Jesus said: 'Whoso eateth my flesh, and drinketh my blood, hath eternal life; and I will raise him up at the last day ...He that eateth my flesh, and drinketh my blood, dwelleth in me, and I in him" (John 6:54, 56).

Many other examples of scientific truth in Scripture could be cited from practically every field of physical, biological or social science. One further example, which is very important, will be given.

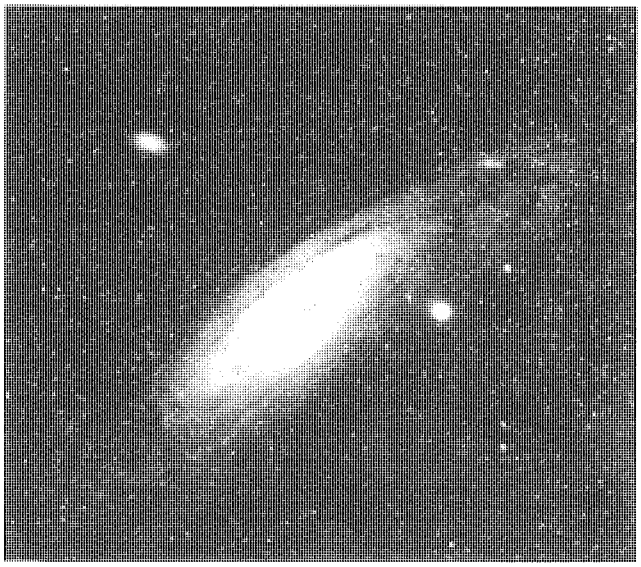
The basic principal of all physical science is that of the conservation and deterioration of energy. The law of energy conservation states that in any transformation of energy in a closed system from one sort into another, the total amount of energy remains unchanged.

A similar law is the law of mass conservation, which states that although matter may be changed in size, state, form, etc., the total mass cannot be changed. In other words these laws teach that no creation or destruction of matter or energy is now being accomplished anywhere in the physical universe.

This law is absolutely basic and of prime importance in all physical science (the law of mass conservation is actually a special part of the law of energy conservation). It was demonstrated quantitatively by science only about a hundred years ago. However, the Bible has taught for thousands of years the same great truth that creation is no longer going on (contrary to the philosophy of continual evolutionary creation), but rather that the present system is merely the result of an original divine creation, which of course is something that would not be susceptible of experimental study at the present time. For example, Hebrews 4:3 affirms: "The works were finished from the foundation of the world." Genesis 2:1-2 says: "Thus the heavens and the earth were finished, and all the host of them. And on the seventh day God ended his work which he had made".

This law of mass and energy conservation is also known as the first law of thermodynamics, and is almost without controversy the most important and basic law of all physical science. As we have just seen, it was anticipated by the biblical record of a finished creation.

The second law of thermodynamics, of almost as great significance, enunciates the corollary law of energy deterioration. In any energy transfer or change, although the total amount of energy remains unchanged, the amount of usefulness and availability that the energy possesses is always decreased. This principle is also called the law of entropy



increase, "entropy" being a sort of mathematical abstraction which is actually a measure of the non-availability of the energy of a system.

Thus, in any closed mechanical system, regardless how large or how small, the energy of the system must continually be degraded, as long as any energy change is taking place in the system-with some of the energy being dissipated in nonrecoverable friction or heat energy. Since all activities of nature (including biological activities) involve such energy transfers, there must be an ever decreasing supply of usable energy for maintaining such processes in the universe as a whole.

This law of entropy increase is responsible for the fact that no machine can be constructed to 100 percent efficiency and that a perpetual motion machine is impossible. It is of primary importance in the writer's fields of fluid mechanics and hydrology, and in all other disciplines of physical science as well.

Practically all the earth's energy, except its atomic energy, comes, or has come, from the sun. However, by far the greater part of the tremendous amount of energy that the sun is continually radiating is dissipated in space in the form of unrecoverable heat energy. This prodigious waste of energy cannot last forever. Eventually, barring supernatural intervention, the sun must burn itself out, and then all activity on the earth must cease as well. The same principle applies to all the stars of the universe, so that the physical universe is beyond question, growing old, wearing out and running down.

But this law certainly testifies equally to the necessary truth that the universe had a definite beginning. If it is growing old, it must once have been young; if it is wearing out, it must once have been new; if it is running down, it must first have been "wound up". In short, this law of energy degeneration conveys us back inexorably to an affirmation of the necessary truth of the existence of a Creator, and a definite creation, which must have taken place in the past but which, according to the law of mass and energy conservation, is not continuing in the present.

But now let us note the teaching of Scripture concerning this principle of deterioration. For example, Psalm 102:25-27 says: "Of old hast thou laid the foundation of the earth: and the heavens are the work of thy hands. They shall perish, but thou shalt endure: yea, all of them shall wax old like a garment; as a vesture shalt thou change them, and they shall be changed. But thou art the same, and thy years shall have no end".

There are many other passages of similar import in the Bible. Thus, the Scripture teaches that which science has only discovered in the past hundred years, namely, that in spite of an original completed creation, the universe is aging and heading inexorably toward ultimate physical death.

However, the Bible also speaks often of that which science cannot discover: a future supernatural intervention of the

Creator in His creation, destruction of the present system, and creation of new heavens and a new earth, which shall continue and wherein dwelleth righteousness (Rev. 21:1; Isa. 65:17;66:22; II Peter 3:13).

An allied truth to these just considered, alluded to previously, is also indicated in Scripture. This is the basic equivalence of mass and energy, one of the most important discoveries of twentieth century science. It is well known now that matter is actually one form of energy, or better, is a manifestation of that form of energy known as atomic energy. The source of the tremendous energy of the atom is yet unknown and may be, in fact, undiscoverable by science. However, it is certain that a tremendous supply of energy from some source (or rather, tremendous power, since power is the rate of energy supply or expenditure) is necessary to maintain the terrific motions and forces associated with the various subatomic particles. The magnitudes of such energies are graphically intimated in the energy released by atomic disintegration.

Most significant, then, is the proclamation of Hebrews 1:2-3: "God ... hath in these last days spoken unto us by his Son, whom he hath appointed heir of all things, by whom also he made the worlds; who being the brightness of his glory, and the express image of his person, and upholding all things by the world of his power, when he had by himself purged our sins, sat down on the right hand of the Majesty on high".

This passage teaches that all things-that is, the matter of the physical universe-are maintained by energy or power, the source of which is the Creator Himself, the Lord Jesus Christ!

The same tremendous truth is taught in Colossians 1:17, which is accurately translated in the American Standard Version "... in him (Christ) all things hold together".

Then in Hebrews 11:3 appears the following remarkably scientific statement: "Through faith we understand that the worlds were framed by the word of God, so that things which are seen were not made of things which do appear". In other words the matter of the universe is not ultimately physical but is composed of something which is not "apparent".

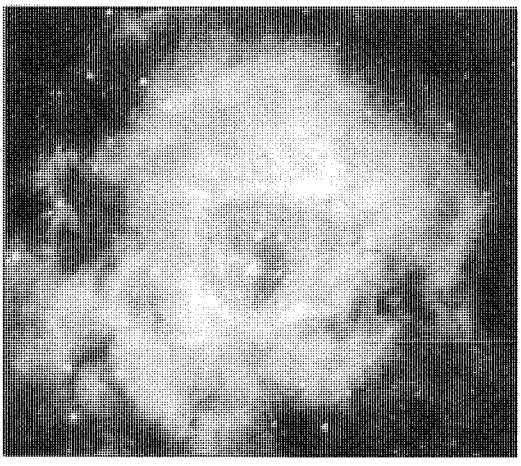
The Greek word for "worlds" in this verse means "world-times" and, in this context, might well refer to the nature of the universe as a continuum of space, mass and time, thus anticipating the modern scientific and relativistic view of the universe. Not only does this statement again emphasize the fact that the material substance of the universe is upheld by the divine Word, but even more that it came into existence by that Word. That is, the universe was not produced out of preexisting chaotic matter of some kind; rather, it was created ex nihilo- "out of nothing" - nothing apparent to the physical senses, that is, but out of the infinite reservoir of energy of the all-powerful Word of God. It is significant that this marvelous "faith" chapter, Hebrews 11, begins with such an eloquent assertion of the necessity of understanding by faith the fact of a primeval special creation.

We have now looked at approximately a score of examples of modern scientific knowledge recorded in Scripture thousands of years before they were discovered by man. This ought to be abundantly convincing evidence of the supernatural source and inspiration of the Bible. But now let us examine briefly some of the best known examples of supposed scientific error or contradiction in the Bible.

The ancient question, "Where did Cain get his wife" has always been the stock objection of shallow-thinking critics. The story of Cain, who was probably, although it is not definitely so stated, the eldest son of Adam and Eve, is found in Genesis 4. It is stated that, as a result of his murder of Abel, he was condemned by God to be "a fugitive and a vagabond". He went out to the land of Nod, on the east of Eden, where according to verse 17, "Cain knew his wife; and she conceived, and bare Enoch: and he builded a city". This is gleefully pointed to as a glaring inconsistency, since Cain is supposed to have been the only person living at that time, other than Adam and Eve.

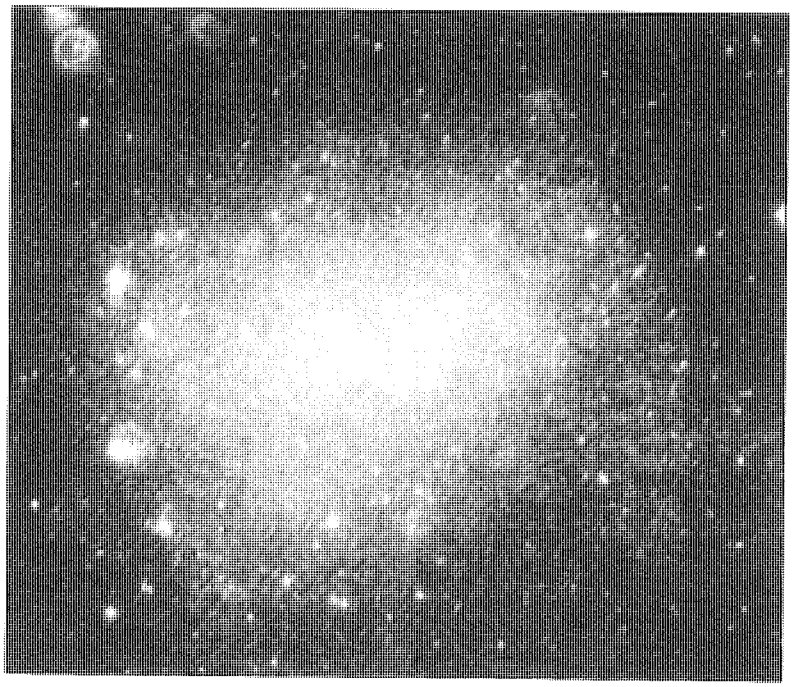
However, this supposition is entirely unwarranted. Nowhere is the statement made that he was the only living child of Adam at that time. It is stated elsewhere, however, that Adam had sons and daughters, mentioning, in addition, that he lived 800 years after the birth of Seth, who was probably, though not necessarily, his third child. In all, Adam lived 930 years. The general rule of that day seemed to be longevity and prolificness. In fact, the first command given Adam and Eve was to "be fruitful and multiply". Furthermore, the ability to have children seemed not to be much reduced by advancing age. It is stated that Noah, for example, was 500 years, old before he begat Shem, Ham and Japheth.

These years, incidentally, are not to be understood as shorter than our years, as there is no substantial basis for this belief. Although we may not be able actually to prove or disprove the



longevity of the ancients, at least the Bible is consistent within itself.

If we accept then the implication that men lived hundreds of years and continued to have sons and daughters most of their lives, and then adopt marriage and birth rates that are very conservative compared with our present rates, it can be calculated quickly that there were at least twenty million people on the earth at the time of Adam's death. There would have been an ample selection from which Cain could choose a wife in plenty of time to build a great many cities. Of course, some son of Adam had to marry his sister. But it is foolish to assert that, in that early day before disease and the evils of inbred heredity had begun to have the effects they have now, such a union would result in feebleminded or deformed offspring.



The story of Jonah and the whale also has been difficult for many to believe. It was formerly claimed that no whale possessed a gullet large enough to admit a man, for example. However, it is now known that there is at least one whale, which inhabits the Mediterranean, which is quite capable of swallowing a much larger object than a man. There are also a number of other fish with sufficiently large gullets, and it may be significant that the Bible account speaks only of a "great fish", not necessarily a whale. There have been a number of accounts, some of them well authenticated, of men in modern times having been swallowed by the sperm whale or some other sea monster, and then later being rescued alive. However, if necessary, there is no reason for us to refuse to believe in an actual miraculous intervention by God in the preservation of Jonah's life. The Lord Jesus (Matt. 12:40) accepted the story of Jonah as authentic history, and even used it as a type or symbol of His own coming death and resurrection.

We shall consider one other case - the long day of Joshua. This supposedly incredible story is found in Joshua 10. In the great battle between the Israelites and the confederation of the Amorites, it is related how "the LORD fought for Israel" by two miracles: (1) causing the sun and moon to be inactive (not "stand still" as incorrectly rendered in the translation) and "hasting not to go down about the space of a whole day" in order to give the children of Israel time to completely defeat the Amorites before nightfall; (2) sending a great hailstorm, which probably served the twofold purpose of giving Joshua's army relief from the terrific heat and of slaying large numbers of the enemy. One frequent objection to this story is that it speaks of the sun stopping its revolution about the earth, whereas it is really not the sun but the earth which is moving. However, elementary physics recognizes that any motion must be measured in relation to some assumed fixed point of reference. The location of this point (since a point of absolute fixity in the universe is completely unknown) is totally arbitrary and should be chosen in the way that best meets the convenience of the observer. The selection of the earth's surface as the reference plane by which to measure the motion of the sun and moon, as Joshua did, is thus perfectly logical and scientific.

Another objection is that, if the earth suddenly stopped rotating on its axis, everything on the surface would be violently dislocated and probably destroyed. However, there is no intimation that the stoppage was sudden instead of gradual. (If an automobile traveling at high speed is instantaneously stopped, great damage ensues to its occupants; but if it gradually slows to a halt, they of course feel no disturbance). It is true, however, that the circulation of the atmosphere would be affected, since it is controlled to some extent by the earth's rotation. This fact probably accounts for the tremendous hailstorm which accompanied the miracle.

If this event actually took place, accomplished by a temporary slowing down of the rotational speed of the earth, it would be reasonable to suppose that people over the whole earth would have noticed it and made some record of it. However, these would now be preserved, if at all, only in the form of semimythical recollections of the event handed down in the folklore of these peoples, since written records of that period (about 1400 B.C.) have not been found at all, except in the Bible and in the fragmentary records of certain nations near the eastern shore of the Mediterranean.

It is significant, therefore, that intimations of such an event can be noted in the mythologies of many peoples from various parts of the earth. So frequent is the occurrence of these, in fact, that they have even been used to bolster the theory that the biblical account was derived from them. For example, T.W. Doane in his book Bible Myths describes accounts of a long day, similar to that of the Bible, in the Orphic hymns, in the legends of the Hindus, the Buddhists, the Chinese, the ancient Mexicans and others, and then draws the very dubious conclusion that the biblical record was therefore derived from such as these.

One of the most persistent of the legends of the various American Indian tribes is that of the theft of the sun for a day, according to M.W. Stirling, in the 1945 Report of the Smithsonian Institute, as well as numerous other ethnologists. A very similar legend is found among the Polynesians. The Greek legend of Phaethon, who disrupted the sun's course for a day, could easily have been derived from this event. Herodotus, the Greek historian, states that the priests of Egypt showed him records of such a day. Other mythological reflections of the long day might also be noted, but it should already be evident that the account in the book of Joshua is accompanied by semimythical records from all parts of the world, of just the sort that one would expect to find if the event

had actually taken place.

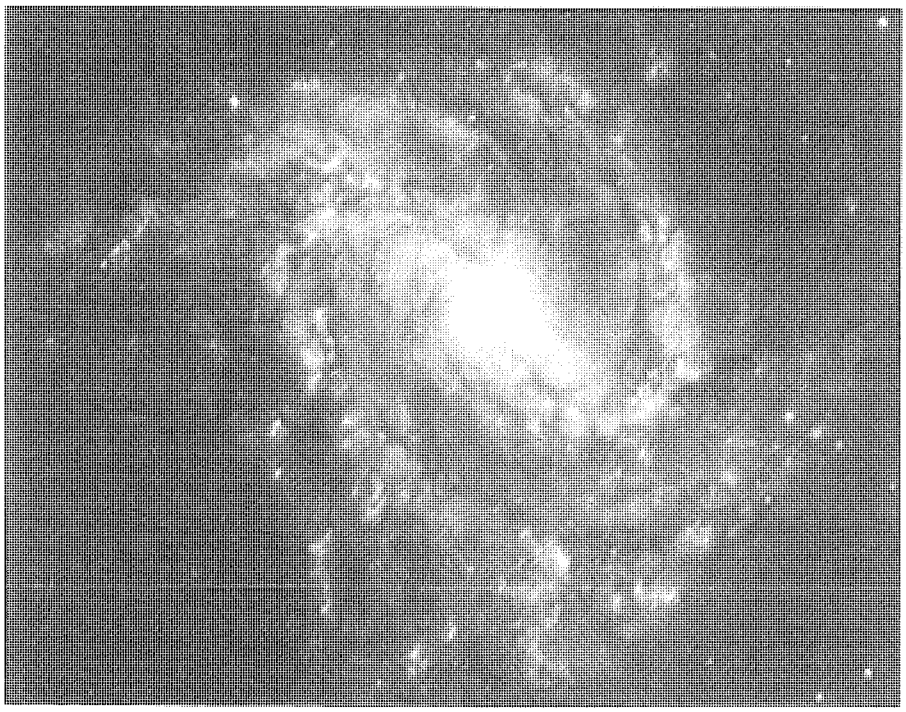
The long day was undoubtedly a supernatural event, but in view of the fact of the existence of a personal God, interested in His creation and its ultimate purpose, it is foolish to say, as some have said, that miracles are impossible. God has planned and maintained a very efficiently working universe, normally subject to the operation of its regular laws. However, it is eminently reasonable that, if God's purposes were better served thereby, He would be expected on occasions to intervene in the normal operation of the socalled "natural laws". In fact, even these laws, as we have seen, along with all things in the physical universe, are actually upheld and maintained directly by the power of God.

The question then in the case of any alleged miracle is not whether it could happen, but whether it did happen. The question should certainly be decided in the affirmative if both of the following conditions are satisfied: (1) that there existed adequate reason in line with God's ultimate purposes, for God to intervene in the normally operative laws of nature; (2) that there exists adequate testimonial or other evidence to its actual occurrence, evidence such as would be judged adequate to prove other factual matters, not necessarily miraculous in nature.

It is believed that both these conditions are abundantly satisfied in all of the biblical miracles. With regard to Joshua's long day, there was quite sufficient reason for God to perform such a miracle at this time. The success of Joshua's entire campaign depended on victory in this battle, and thus also the fulfillment of God's promises to the world through the nation Israel. Furthermore, the Canaanite peoples were sun worshippers, and it may well have been that God chose to accomplish their defeat through the instrumentality of their supposed god, in order to demonstrate better the falsity of their exceedingly cruel and licentious religious system. It should also be remembered that the miracle followed immediately upon Joshua's command, uttered no doubt as a prayer of implicit faith. God answers prayer many times in very remarkable ways, as all who truly know the Lord Jesus can testify. He has even promised to remove mountains in answer to genuine faith. He had made a specific promise to Joshua in regard to the Canaanite campaign and this particular battle. If needed, still other reasons might be adduced to indicate the necessity for this miracle.

As to the evidence for it, the very fact that the story appears in the Bible is itself strong evidence. As we shall see later, the historical portions of the Bible have been substantiated in scores of instances by archaeological research, including especially many phases of Joshua's conquests. Historically, the Bible is now believed by nearly all authorities in Palestinian archaeology, even by those who deny its supernatural inspiration, to be a very valuable and trustworthy book. Also, as we shall see, there are many other independent lines of evidence corroborative of the doctrine of inspiration.

The widely publicized theories of Velikovsky may be mentioned in this connection, according to which the earth has experienced a number of severe physical catastrophes in the past. These were attributed by him to the near approaches of a huge comet to the earth, one of which he supposed caused the stopping of the earth's rotation in the days of Joshua. Dr. Velikovsky amassed a really impressive amount of evidence from the myths and legends of many peoples that such a "long day" had actually been recorded and observed all over the world. However, his explanation of its cause is beset by many difficulties and has not been taken seriously by scientists; his whole work therefore is largely ignored. Nevertheless, he did point out a great amount of evidence supporting the fact of the long day, even though his ideas concerning its cause were unscientific (and, of course, unscriptural as well).



All true Christians believe in God the Father, God the Son, and God the Holy Spirit, and that these three, though distinct from one point of view, constitute only one God. Many, of course, have scoffed at this belief that God is one Person and, at the same time, three Persons. It is contrary to established and inalterable mathematical principles, they say, for Christians to maintain that 1+1+1=1, rather than 3. It is unscientific and foolish, they are agreed, that the God of the universe (even though they should grant for the moment that He might be a real personality) could be both one personality and three personalities at the same time. Therefore, it follows for them, that Jesus was not God in the biblical sense at all.

However, as Dr. Nathan Wood, former president of Gordon College, has shown in a very remarkable volume, the doctrine of the Trinity is not only sound mathematically but is reflected in all true science in such a wonderful way that the assumed fact of an eternally existing triune God is an inductive necessity before the universe, as science knows it today, can be explained at all.

The doctrine of the Trinity is nowhere set forth in the Bible as an explicit doctrine. Rather, it appears indirectly, and yet perfectly naturally, as Jesus speaks of Himself and of the Father and of the Holy Spirit. Always the logical, causal order presented is: first God the Father-the unseen source and cause of all things; second, God the Son-who tangibly and visibly reveals the Father to man and who executes the will of God; third, God the Holy Spirit-who is unseen and yet reveals God the Son to men through the media of other men and the Word

which He inspired, and who makes real in the hearts and lives of men the experience of fellowship with the Son and the Father. Yet this is not an order of importance or length of existence. All are equally eternal and equally God-one God. The Son is presented as "begotten of the Father", the Spirit as proceeding from the Father through the Son.

Now consider the physical universe which logically should reflect in a very untimated way its Creator. All knowable things in this universe may be classified under the heads of space, matter or time. Now space, at least as far as we can comprehend it, consists of exactly three dimensions, each equally important and absolutely essential. There would be no space, no reality, if there were only two dimensions. Three distinct dimensions exist, yet each comprises the whole of space. Yet there is just one space. Note that to get the cubical contents of any certain confined space, one does not add the length and breadth and width, but rather multiplies them together. Analogously, the mathematics of the Trinity is not 1+1+1=1, but 1x1x1=1.

The analogy is even more striking in matter. The new physics has come to regard matter more and more as "simply" tremendous energy in motion. Depending on the rates and types of motion, there are then various phenomena presented to our senses - sound, color, heat, texture, hardness, etc. Energy is the unseen source manifesting itself in motion and thus producing phenomena. Matter involves these three phases and no others that cannot rightly be included in one of these. Each is distinct, yet each involves the whole of matter, and none of the three can exist but itself without the other two. Energy is first in a logical, causal order, but not in order of importance or precedence. Motion, which embodies, reveals and is begotten of energy, is the second. Phenomena proceed from motion and comprise the ways in which motion itself touches and affects men, even as the Holy Spirit reveals the Son and, through Him, the Father to men.

Finally, the last of the triad, time, is one entity but consists of the future, the present and the past. Each contains the whole of time, yet is distinct and, further, cannot exist without the other two. The future is the unseen source of time and is embodied and made real, moment by moment, in the present. The past then proceeds from the present, becoming invisible again, yet continually influencing us with regard to the present and even, to some extent, the future.

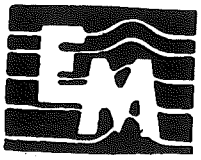
Furthermore, the three basic entities unite to form the space-mass-time continuum which constitutes the physical cosmos itself. Space is the invisible, omnipresent background, manifest everywhere in matter (or more generally, energy), interpreted and experienced through time. Thus the physical universe is actually a trinity of trinities, a tri-universe in the fullest sense.

But this same remarkable phenomenon can be seen in the realm of human life as well. The Bible says that man was created in the image of God, so this should be expected.

Notice that each individual is a person who can be physically observed and described. But back of that person is his nature, which is unseen and yet is the source of all that the person embodies. But that person, and through the person his nature, is known to other men only through his personality, which is an unseen, intangible thing, yet the means by which the person touches the lives of others. So human life consists of three things-nature, person and personality-and no others. Although they are equally important and equally the whole of the man, yet they always exist in the above logical order. None of the three can exist without the other two. The nature is the source, revealed and embodied in the person. The personality proceeds from the person. It is invisible but is felt by and has influence on the lives of others in regard to the person. Thus man is, in minute detail, a finite reflection of God who made him in His own image. It is true that sin has marred even this finite reflection, nevertheless man still reflects the image of God in an even more significant way than does the physical universe.

This same triunity seems to pervade everything in life. Every moral action of man consists of: first, the motive; second the act; third, the consequences. The same relations apply among these as among the triunities we have already mentioned. Similarly, all forms of thought or reason proceed logically from the universal to the particular thing to that thing as related to other things.

This triunity of source, manifestation and meaning could be further noted in many other areas of the world and life. But even this brief discussion should suffice to indicate something of the basic system of three-in-oneness pervading the whole creation. While these facts cannot be held to prove that the Creator of the universe and of life is a triune Being, it should be obvious that such a cause would be eminently adequate to account for all these facts. It is certainly difficult and perhaps impossible to formulate any other hypothesis as satisfactory as this to account for the existence of such universal triunity in nature. The doctrine of the Trinity is no unscientific, aboriginal absurdity, but an intensely scientific and tremendously important living reality. God was manifested and revealed by and in His Son, who as a man was Jesus Christ. There can be nothing more important for any individual then, than to become rightly related to this triuniverse and its triune God. This means unreserved acceptance of Christ, for "in him dwelleth all the fullness of the Godhead bodily" (Col. 2:9).



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MODELING OF REPTILES AND PELYCOSAURS USING THE FINITE DIFFERENCE METHOD

George Florides, Senior Instructor, Workshop Department, H.T.I.
Dr. Kalogirou Soteris, M.Phil., Ph.D., Eur Ing, C.Eng., MCIBSE, MASHRAE, MISES,
Laboratory Assistant, Mechanical Engineering Department, H.T.I.

ABSTRACT

This paper deals with the thermal analysis of reptiles and pelycosaurs. A step by step analysis of all the energy budgets affecting the body temperature of the animal is presented. In the analysis the behaviour of the animal, energy gains and losses due to metabolism, evaporation, solar heat, convection, and radiation are considered. The effect of the sail that existed at the back of pelycosaurs is also examined. Finite difference equations are derived that take into account all the above factors. The computer program used to find the body temperature of the animal is presented. The program is written in such a way as to allow evaluation of the effect of the rate of the animal blood flow. The results of the computer model are compared with results of programs using one cylinder to present the body of the animal and runs at different weather conditions for large lizards and pelycosaurs are examined. The sail of pelycosaurs was giving an advantage to the animal warming it up quicker in the morning of cold environments.

1. INTRODUCTION

Reptiles are animals that do not have steady body temperature and are affected by the ambient temperature. Reptiles are ectotherms and since they cannot generate sufficient heat to reach their functioning temperature they use outside sources to warm up in cold environments.

Living reptiles are the alligators and crocodiles (order crocodilia), lizards and snails (order squamata), the tuatara (order rhynchocephalia), and turtles or tortoises (order chelonia). This paper indicates a practical way of examining the thermal energy budgets (heating and cooling) of the bodies of ectotherms. The function of a peculiar biological structure that existed at the back of Pelycosaurs (see Fig. 1), which were primitive reptiles that lived during the Permian geological period is also examined.

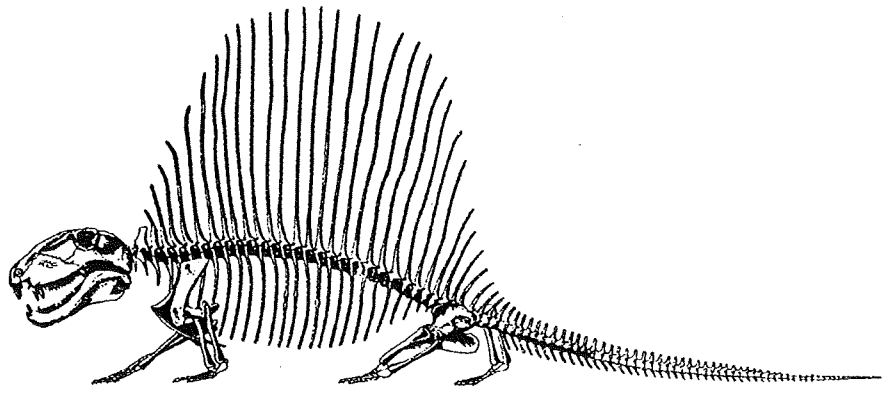

Fig. 1. Skeletal restoration of Dimetrodon limbatus. Male, length as restored, 283 cm. (Romer and Price, 1940)

The upnormal development of the vertebral spinous processes of animals belonging in the Order of Pelycosauria (like Dimetrodon and Edaphosaurus) has excited considerable comment in the past. A possible use of the structure was to function as a thermoregulator to help in stabilizing the animal's body temperature and therefore maintain a more efficient metabolism. With this method, which today is the most widely accepted view, pelycosaurs would have a distinct advantage since by warming up as fast as possible in the morning sun they would be able to outrun both their prey and rivals.

In this paper an analysis of the energy budgets affecting the body temperature of the animal is presented. In the analysis, factors like the behavior of reptiles, metabolism, evaporation, and gains and losses from the environment are taken into account. Finally typical runs of the program written for this purpose are presented in order to show the effect of the above factors on the body temperature of the animal as well as the effect of the sail.

1.1. Importance of Body Temperature

The range of temperatures at which a particular animal will function, probably depends on the way that enzymes function. Enzymes are proteins that catalyze the chemical processes occurring within living cells. Most enzymes work best within a particular and usually narrow temperature range. If an enzyme is exposed to temperatures outside this range, its catalytic powers are reduced or eliminated (McGowan , 1991).

Active reptiles have average body temperatures of about 35 °C, i.e., a value which is lower than the temperature of most mammals (37 °C) and birds (40 °C). Probably there is much variation from reptile species to species (McGowan, 1991).

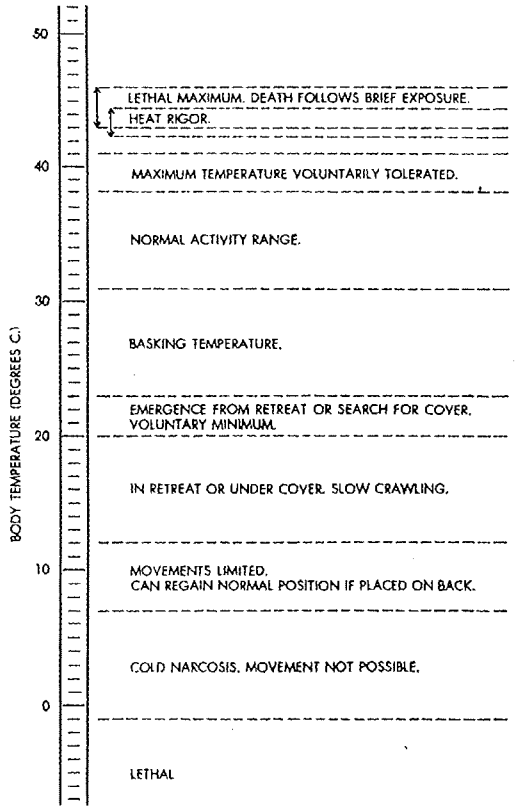

Fig. 2. The significance of body temperature to the behavior of reptiles (Bogert, 1959).

A factor which plays an important role in the loss or gain of heat is the volume of an animal and its associated external area. Since animals can absorb or loose heat through their skin small animals can heat up and cool down more rapidly than large animals. The snakes have gotten around the surface-to-mass limitation by the lengthening of their bodies, which exposes more surface per unit mass to absorb solar energy (Bogert, 1959).

To understand the way the body temperature of ectotherms is regulated, the strategies used by reptiles and their metabolism need to be examined.

1.2. Strategies Used by Reptiles to Regulate Their Body Temperature

In a cold environment reptiles warm themselves by absorbing heat from the sun. This can be done by basking in the sun. Lizards orient their bodies at right angles to the sun's rays in order to maximize their exposure and seek inclined surfaces to achieve the best orientation with respect to the blunting rays of the morning sun.

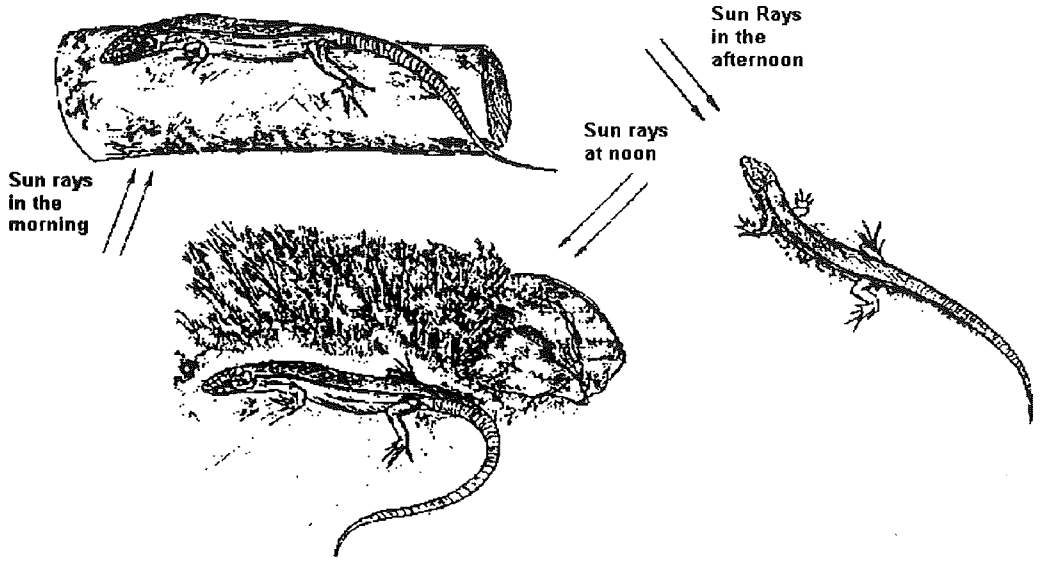

Fig. 3. The behavior of lizards.

In the desert where the ground becomes warmer than the air, lizards often press their bodies close to the surface, shifting slowly from side to side in the loose sand to secure better conduction of heat. On a rocky mountainside that warms up more slowly, they do their basking on pats of dead grass that insulate them from the cold ground (Bogert, 1959). Once they reach their working temperature they become active. Also when they are too hot they seek the shade or move underground. Later they emerge from the shade and lie parallel to the sun's rays (see Fig. 3).

In addition to the above behavioral factors, a reptile can control its body temperature by the following physiological means :

(a) Changes in colour.
(b) Changes in ventilation and evaporation.
(c) Changes in blood flow.
(d) Changes in metabolic rate.

2. ENERGY BALANCE

The different factors that affect the energy exchange between the animal and its surroundings are discussed below.

2.1. Metabolism and Reptiles

All living cells generate small amounts of heat as a by product of the chemical processes occurring within them. This chemical activity is called metabolism. Active cells, especially muscle cells generate much more heat that resting cells.

The rate of chemical reactions depends on the temperature. This rate increases rapidly with increasing temperature and as a generalization it can be considered that for every ten degree change in body temperature (in °C), the rate of physiological processes double. This phenomenon is called the Q10 effect (Bakker,1988).

Bennett and Dawson, (1976) in their study for Metabolism mention that the cost of maintenance has been a conservative parameter during reptilian evolution. This suggests that the primitive metabolic condition of this group was similar to that observed in its modern representatives.

Bennett and Dawson, (1976), have gathered all available data and formulated equations describing metabolic rates during rest and activity. These equations are used in the study. Reptilian activity also depends to a considerable extent on anaerobic processes which must be considered.

2.2. Evaporation

Ectotherms cannot loose heat by sweating in the way a mammal or bird can (Bakker,1988) but they can loose heat cutaneously and from respiration.

Evaporation data are tabulated for *Alligator mississippiensis* by Spotila *et al.* (1972). These data can be used in calculating evaporation at different body temperatures.

2.3. Solar Heat

The sun is the main source of energy supplied to an ectotherm. For estimating the energy balance at every time interval, the solar heat absorbed during this interval by the body surface of the animal is calculated, by considering the beam and diffuse radiation that falls on the animal. For this analysis the formulation developed by Duffie and Beckman (1991) is followed.

2.4. Convective Heat Loss

Convective heat loss is a complicated phenomenon which depends on the area, shape and texture of the convective surface, the difference in temperature between the surface and the free stream air temperature, the state of motion of the air and other thermophysical properties. Beckman *et al.* (1971), have experimented on Disposaurus (desert iguana). They have produced an aluminum casting and gold-plated it, to minimize the effect of radiant heat transfer in order to find the relation between Nusselt and Reynolds numbers. The obtained results in the wind tunnel, based on the snout-vent length (L) were:

$Nu=0.35Re^{0.6}$ for transverse flow (1)

$Nu=0.10Re^{0.7}$ for parallel flow (2)

The maximum heat transfer coefficient, which can be obtained from Eq. (1) is used in the calculations.

The convection heat loss for the sail, which can be treated as a simple plate, can be calculated from the formula: $Nu = 0.86\ Re^{0.5}\ Pr^{0.333}$

In the above formula, which is valid for flat rectangular plates at various orientations in a wind tunnel, the characteristic length (L_S) is four times the plate area divided by the plate perimeter.

According to Duffie and Beckman, (1991) this formula can be used for Reynolds numbers up to 10^6. Also they suggest that the wind tunnel results should be increased by approximately 0.25 for outdoor conditions. Therefore in this study the following formula is used: $Nu = Re^{0.5}\ Pr^{0.333}$ or $Nu=0.891\ Re^{0.5}$

Solving the above equation for the sail convection coefficient (h_s) :

$$h_s = 0.891\frac{k}{L_S}\left(\frac{UL_S}{\nu}\right)^{0.5} \quad (3)$$

2.5. Radiation Heat Loss

If heat is transferred by radiation between two gray surfaces the following simplified equation can be used with adequate accuracy:

$$Q_{12} \approx 6\varepsilon_1 A_1\left(T_1 - T_2\right) \quad (4)$$

In this case T_1 is the skin temperature of the reptile and T_2 is the effective sky temperature.. The effective sky temperature is always lower than the air temperature but when there is a low cloud cover or ground radiation it can be assumed that the effective sky temperature is equal to the air temperature near the ground. The emissivity (ε) of most biological materials is 0.95 (Haack, 1986).

2.6 Model Assumptions

The following assumptions are followed in the study:

1. The body of the animal consist of four cylinders. One cylinder represents the head, two the main body and one the tail.
2. The core of every cylinder is assumed that is at uniform temperature. Skin and fat in layers of different temperatures will cover the cores.
3. Heat is transferred from or to the cylinders radially only.
4. There is no heat loss from the end of the cylinders.
5. There is no heat exchange longitudinally between the insulation (skin and fat) of the cylinders, i.e., there is only radial heat flow.

6. The heat from metabolism and evaporation, in the model, spreads equally between the two cylinders of the main body where nearly all the activity takes place.
7. The temperature of every core section is averaged every a certain amount of time, assuming that all the blood passes from the heart in that time. This actually depends on the activity and heart rate and the efficiency of the heart .The new core temperature is used as a basis for the next time interval. The averaging of the core temperature is on the basis of the mass $(m_1,...,m_4)$ of every section, to the total (m_{total}), i.e.,

$$T_{average} = (m_1 Tc_1 + m_2 Tc_2 + m_3 Tc_3 + m_4 Tc_4) / m_{total} \quad (5)$$

8. The animal is not touching the ground and no heat is transferred by conduction. In reality the animal would lie on the ground when the ground temperature was higher than the surrounding temperature but at the same time it would loose more heat from the external area of its limbs. It is assumed that one effect is compensating for the other.
9. The sail if present is treated as a simple vertical plate.
10. The sail pumps heat directly to the core.

3. THERMAL ANALYSIS USING FINITE-DIFFERENCE EQUATIONS

3.1. Thermal Behaviour of the Body

Every cylinder is assumed to consist of a core at uniform temperature and a series of skin and fat layers. The theoretical approach for calculating the temperature of each layer is based on Fig. 4.

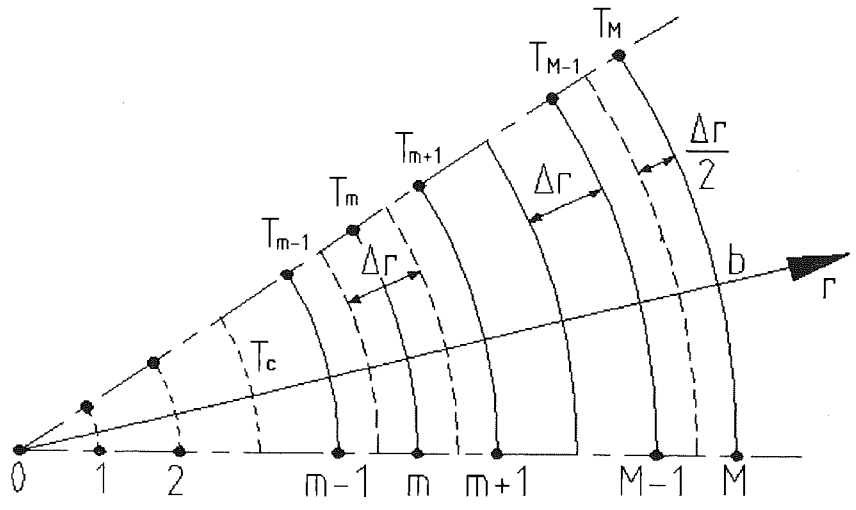

Fig. 4. Nomenclature used for the finite difference equations.

Calculation Of The Temperature Of Each Layer.

For steady state one-dimensional heat flow the equation at m gives:

$$\frac{T_{m-1} - T_m}{R_{m-1,m}} + \frac{T_{m+1} - T_m}{R_{m+1,m}} = 0 \quad (6)$$

Substituting the above values of $R_{m-1,m}$ and $R_{m+1,m}$ (where R is the thermal resistance = Δr /Ak), and rearranging the equation we get:

$$2\pi mkL\left[(1-1/2m)T_{m-1}+(1+1/2m)T_{m+1}-2T_m\right]=0$$

For a time dependent one-dimensional heat conduction problem on a cylindrical region, Fourier's equation states that:

$$\frac{\kappa}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)=\rho c\frac{\partial T}{\partial t} \tag{7}$$

Adopting the concept of thermal resistances to derive finite difference equations as suggested by Ozisik (1987), the above equation can be approximated in the form:

$$\frac{T_{m-1}-T_m}{R_{m-1,m}}+\frac{T_{m+1}-T_m}{R_{m+1,m}}=c_f\rho_f V_m\frac{T_m^{t+\Delta t}-T_m^t}{\Delta t} \tag{8}$$

where R = Δr /Ak is the thermal resistance and V_m is the volume of the element around node *m*. Substituting the expressions of $R_{m-1,m}$ and $R_{m+1,m}$ and rearranging the equation:

$$2\pi mLk_f\left[\left(1-\frac{1}{2m}\right)T_{m-1}^t+\left(1+\frac{1}{2m}\right)T_{m+1}^t-2T_m^t\right]=c_f\rho_f V_m\frac{T_m^{t+\Delta t}-T_m^t}{\Delta t} \tag{9}$$

With reference to Fig.4 the volume of the layer m (V_m) is equal to $V_m=(2\pi m\Delta r)\Delta rL$
By substituting the above value in Eq. (9) and rearranging the terms:

$$T_m^{t+\Delta t}=T_m^t+\frac{k_f\Delta t}{\rho_f c_f\Delta r^2}\left[\left(1-\frac{1}{2m}\right)T_{m-1}^t+\left(1+\frac{1}{2m}\right)T_{m+1}^t-2T_m^t\right] \tag{10}$$

If $F_1=\dfrac{k_f\Delta t}{\rho_f c_f\Delta r^2}$, then by rearranging Eq. (10):

$$T_m^{t+\Delta t}=T_m^t(1-2F_1)+F_1\left(1-\frac{1}{2m}\right)T_{m-1}^t+F_1\left(1+\frac{1}{2m}\right)T_{m+1}^t \tag{11}$$

When at any time step *t* the temperatures T_{m-1}^t and T_{m+1}^t at nodes *m-1* and *m+1* are equal but less than T_m^t at node *m* between them, then the coefficient $1-2F_1$ becomes negative for values of F_1 bigger than $\frac{1}{2}$. Then, according to the finite difference Eq. (11) for $1-2F_1$ negative, the temperature $T_m^{t+\Delta t}$ at node *m* at the next time step should be less than that at the neighbouring two nodes. This is not possible thermodynamically, since it was assumed that T_m^t was higher than the temperature at the neighbouring nodes when deriving the equation. Therefore, to obtain meaningful solutions, the stability criterion is:

$$1-2F_1 \geq 0$$

In this case the above criterion is satisfied when:

$$1 - 2\frac{k_f \Delta t}{\rho_f c_f \Delta r^2} \geq 0 \qquad \text{or,} \qquad \Delta t \leq \frac{\rho_f c_f \Delta r^2}{2\ k_f}$$

Calculation Of The Core Temperature

The core will act as a reservoir summing the rate of heat gain from metabolism (H_m), from the sail (H_s) and from the neighbouring layer and the heat loss from evaporation (E). Therefore the heat stored in the core is equal to:

$$M_c c_c \frac{\left(T_c^{t+\Delta t} - T_c^t\right)}{\Delta t} = H_m + H_s - E + \left(T_n^t - T_c^t\right)\frac{A_c k_f}{\Delta r}$$

Solving for the core temperature after time Δt (seconds):

$$T_c^{t+\Delta t} = T_c^t + \frac{\Delta t}{M_c c_c}\left[H_m + H_s - E + \frac{A_c k_f}{\Delta r}\left(T_n^t - T_c^t\right)\right] \tag{12}$$

by substituting :

$H_{in} = H_m + H_s - E$, $F_2 = \dfrac{\Delta t}{M_c c_c}$ and $F_3 = \dfrac{A_c k_f}{\Delta r}$, in Eq.(12):

$$T_c^{t+\Delta t} = T_c^t\left(1 - F_2 F_3\right) + F_2 H_{in} + F_2 F_3 T_n^t \tag{13}$$

By following an argument similar to that described for Eq. (11), it is obvious that to obtain meaningful results the coefficient of T_c^t must be positive, therefore the restriction in this case is:

$$\Delta t \leq \frac{\Delta r M_c c_c}{A_c k_f}$$

Calculation Of The Temperature Of The External Layer

The external layer gains heat from direct and diffuse solar radiation (Q_{TOTAL}) and looses heat by convection (Eq. 1) and radiation (Eq. 4). Therefore by applying Eq. (6) at M and substituting the value of $R_{M-1,M}$:

$$2\pi M L k_f \left(1 - \frac{1}{2M}\right)\left(T_{M-1}^t - T_M^t\right) - A_M h\left(T_M^t - T_\infty\right) + Q_{TOTAL} - 6\varepsilon_f A_M\left(T_M^t - T_\infty\right) = 0$$

For the above equation Δr is considered to be sufficiently small so that the heat capacity associated with the volume element at the boundary node can be neglected, i.e., a steady state energy balance at the boundary is assumed.

If Δr is not considered to be sufficiently small, the effect of the heat capacitance can be included by considering a time dependent energy balance for the volume element associated with the node at the boundary. The energy balance is applied to a volume element of thickness $\Delta r/2$ as shown in Fig. 4. The equation for calculating the temperature for this layer is:

$$\left(T_{M-1}^{t} - T_{M}^{t}\right)\ 2\pi ML k_f \left(1 - \frac{1}{2M}\right) - A_M h \left(T_M^t - T_\infty\right) + Q_{TOTAL} - 6\varepsilon_f A_M \left(T_M^t - T_\infty\right) =$$

$$= c_f \rho_f \left(2\pi M \Delta r \frac{\Delta r}{2} L\right)\left(\frac{T_M^{t+\Delta t} - T_M^t}{\Delta t}\right) \tag{14}$$

By substituting A_M with $2\pi ML\Delta r$ and solving for $T_M^{t+\Delta t}$:

$$T_M^{t+\Delta t} = T_M^t + \frac{2k_f \Delta t}{c_f \rho_f \Delta r^2}\left(T_{M-1}^t - T_M^t\right)\left(1 - \frac{1}{2M}\right) - \frac{2\Delta t}{c_f \rho_f \Delta r} h \left(T_M^t - T_\infty\right) +$$

$$+ \frac{\Delta t}{c_f \rho_f \left(\pi M \Delta r^2 L\right)} Q_{TOTAL} - 6\varepsilon_f \left(\frac{2\Delta t}{c_f \rho_f \Delta r}\right)\left(T_M^t - T_\infty\right) \tag{15}$$

As above,

$F_1 = \dfrac{k_f \Delta t}{\rho_f c_f \Delta r^2}$. Also if $F_4 = 1 - \dfrac{1}{2M}$, then Eq. (15) becomes:

$$T_M^{t+\Delta t} = T_M^t \left(1 - 2F_1\ F_4 - \frac{2F_1 \Delta r h}{k_f} - \frac{12\varepsilon_f F_1 \Delta r}{k_f}\right) + 2F_1\ F_4 \left(T_{M-1}^t\right) +$$

$$+ \frac{F_1}{(\pi ML)k_f} Q_{TOTAL} + \left(\frac{2F_1 \Delta r h}{k_f} + \frac{12\varepsilon_f F_1 \Delta r}{k_f}\right) T_\infty \tag{16}$$

In this case, the stability criterion is more severe than the criterion for the core and the internal nodes:

$$\Delta t \leq \frac{\rho_f c_f \Delta r}{\dfrac{2k_f (1 - 1/2M)}{\Delta r} + 2h + 12\varepsilon_f} \tag{17}$$

For the numerical calculations, the smallest value of Δt must not be exceeded.

It must be noted that Q_{TOTAL} in the above formulae is the total heat gain from the environment. This is calculated by estimating the total radiation incident on the surface and using a mean absorptivity of the skin (of alligators) equal to 0.9 (Spotila *et al.* ,1972).

3.2. Thermal Behaviour of the Sail

It is believed that the sail of pelycosaurs was covered by a membrane. It also seems that the function of the sail was to carry the heat it absorbed directly to the main blood stream and not to the skin surface.

The two sides of the sail must be treated separately because different amounts of heat are absorbed (Haack, 1986). For every side of the sail (Fig. 5) the energy balance equation, neglecting the effect of the heat capacitance, is:

$$Q_{Tsail} - A_s h_{cs}\left(T_s^t - T_\infty^t\right) - 6\varepsilon_f A_s\left(T_s^t - T_\infty^t\right) - A_s h_x\left(T_s^t - T_b^t\right) = 0$$

solving for T_s^t:

$$T_s^t = \left[\frac{Q_{Tsail}}{A_s} + \left(h_{cs}T_\infty^t + 6\varepsilon_f T_\infty^t + h_x T_b^t\right)\right] / \left(h_{cs} + 6\varepsilon_f + h_x\right) \qquad (18)$$

Equation (18) can be used in the program to calculate T_s^t for the first time. Considering a time dependent energy balance the following equation will apply:

$$Q_{Tsail} - A_s h_{cs}\left(T_s^t - T_\infty^t\right) - 6\varepsilon_f A_s\left(T_s^t - T_\infty^t\right) - A_s h_x\left(T_s^t - T_b^t\right) = A_s\ (t_s)\rho_f c_f \frac{T_s^{t+\Delta t} - T_s^t}{\Delta t}$$

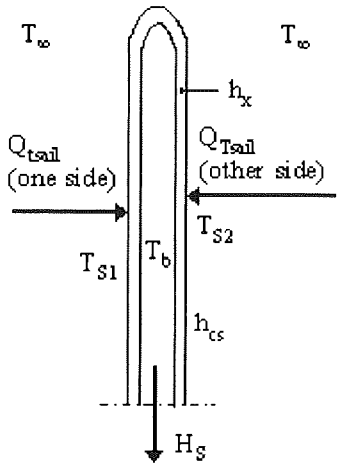

Fig. 5. Nomenclature used for the energy balance of the sail.

Substituting with: $F_s = \dfrac{\Delta t}{t_s \rho_f c_f}$ and solving the above equation for $T_s^{t+\Delta t}$:

$$T_s^{t+\Delta t} = T_s^t\left[1 - F_s(h_{cs} + 6\varepsilon_f + h_x)\right] + \frac{F_s Q_{Tsail}}{A_s} + F_s(h_{cs} + 6\varepsilon_f)T_\infty + F_s h_x T_b \qquad (19)$$

The heat transfer (H_s) to the core is:

$$H_s = A_s h_x\left(T_{s1}^{t+\Delta t} - T_b\right) + A_s h_x\left(T_{s2}^{t+\Delta t} - T_b\right) =$$

$$= A_s h_x\left(T_{s1}^{t+\Delta t} + T_{s2}^{t+\Delta t} - 2T_b\right) \qquad (20)$$

3.3. Computer program

Program "C-4" is constructed by using the above formulae for the simulation of the body temperature of the animal. The flow chart of the program is shown in Fig. 6. The program is constructed in such a way that the behaviour of the reptiles shown in Fig. 3 is followed.

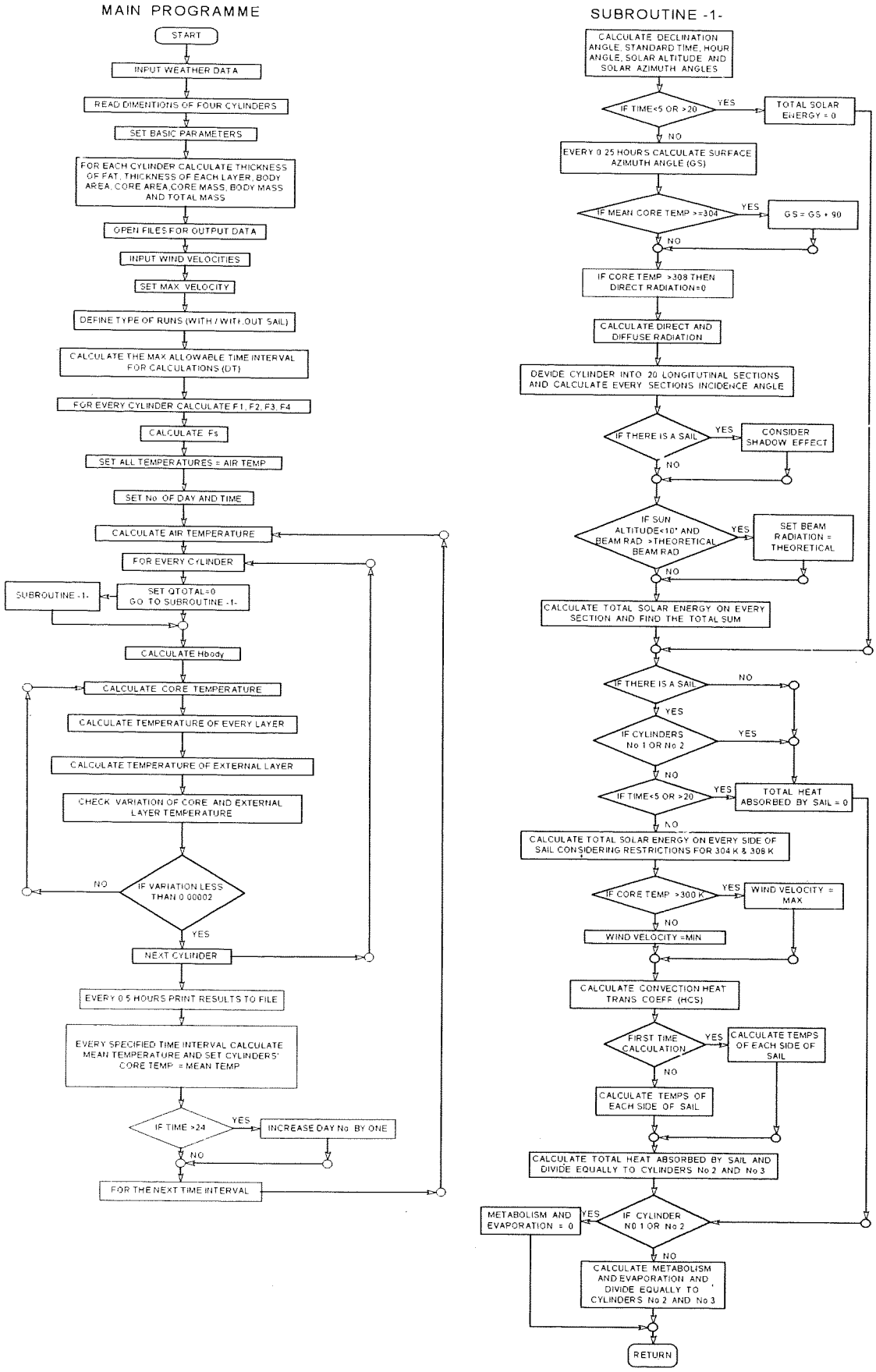

Fig. 6. Program C-4 flow chart.

4. DISCUSION AND CONCLUSIONS

The four cylinders used in the present study provide a means of checking the effect of blood circulation, i.e. the time needed for the body to get to the same uniform temperature, mainly due to blood circulation. Essentially, this depends on the heart rate. Typical runs of the program for an animal with a body weight of 150kg, skin and fat thickness of 1.4 mm, and a total length of 3m, are shown in Fig. 7.

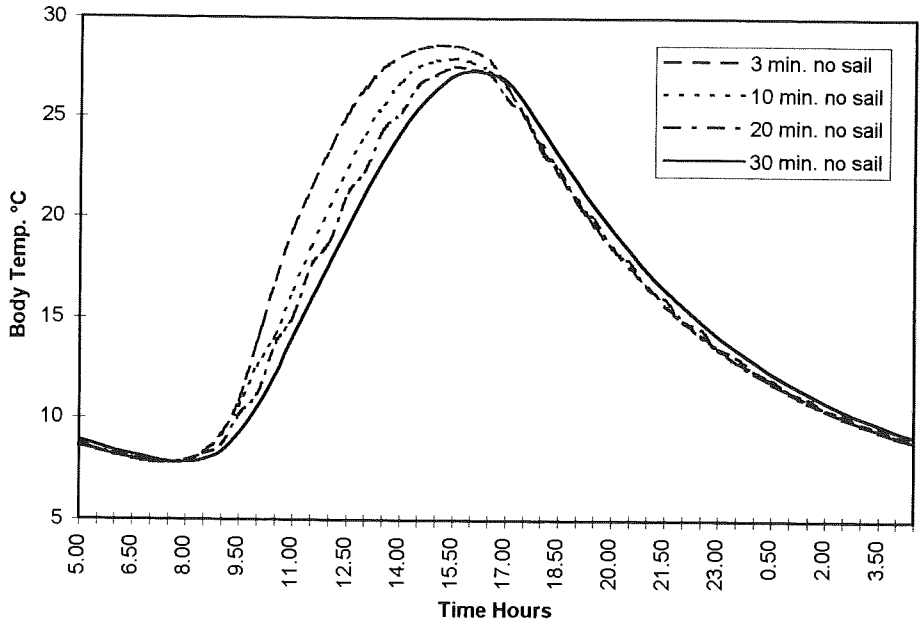

Fig. 7. Typical runs of the program 4-C for blood mixing rates.

As it is shown the blood mixing rate is of great importance. A quick mixing rate allows energy received on the surface of the small cylinders (representing head and tail) to be stored in the main body cylinders, thus minimizing the heat loss to the environment. This also explains the fact that during heating, reptiles increase their heart rate. When the ambient temperature drops the heart rate slows down and in this way lizards cool at a slower rate than that at which they warm up. It must be noted that for every run above, a constant blood flow rate was used. Obviously the animal will adapt the heart rate using a quick rate during the morning and a slow rate during afternoon hours. The steeper increase of temperature during the morning hours also explains why living animals warm up quicker than when they cool down.

Runs for different seasons of the year for an animal with sail (i.e., Dimetrodon Limbatus) and the same animal without sail, are shown in Fig. 8. As it can be seen the sail is giving an advantage to the animal because it could warm up quicker in the morning and it could reach the normal activity range quicker. This advantage is greater in colder environments. In hot environments although the sail gives a small benefit early in the morning it is obvious that at noon the sail could kill the animal with the extra heat which it could absorb.

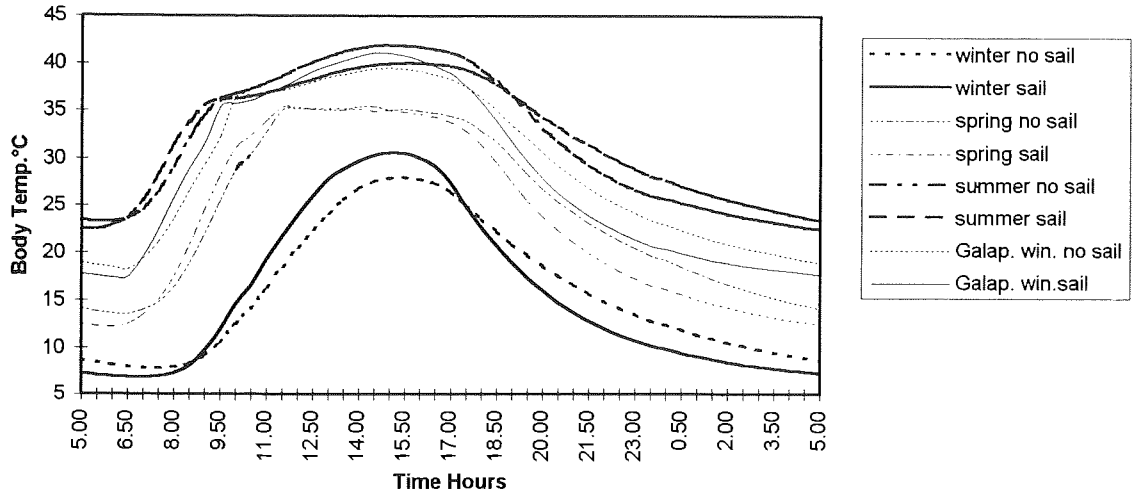

Fig. 8. Runs of program 4-C for different seasons of the year.

The runs of Fig. 8 assume that there is a continuous blood flow to the sail. This has as a result the drop of temperature, during the night hours, of about one to two degrees C. For maximum beneficial result the blood flow to the sail could be minimized, in which case the body temperature could stay a bit higher during the night hours.

As a concluding remark, it should be noted that the method presented here can be applied to any ectothermic animal, either living or extinct, like reptiles and pelicosaurs and the effect of the environment on the body temperature of the animal can be studied in detail.

NOMENCLATURE

A_1 area of emitting surface (m^2)
A_s area of one side of sail (m^2)
c_c specific heat of the core (= 3768 J/kg K)
c_f specific heat of fat (2510 J/kg K or 0.60 cal/g K)
H heat transfer coefficient (W/m^2 K)
h_c convective heat transfer coefficient (W/m^2 K)
h_{cs} convection heat transfer coefficient of sail (W/m^2 K)
h_x heat transfer coefficient from surface to interior of sail (W/m^2 K)
k thermal conductivity of air, 0.026 W/m K (for 25 °C)
L length of the body (m), longitude (degrees)
M_c mass of the core [= specific density of core (ρ_c = 1075 kg/m^3) x volume of core (Vc)] (kg)
Pr (the Prandtl number) = ν / α (for 25 °C Pr = 0.708)
$\dot{Q}_{12}$ the net heat transfer from surface 1 to surface 2
q_s the heat flux from the surface into the fluid (W/m^2)
Q_{ST} stored heat (W)
Q_{Tsail} total heat gain from the environment on one side of sail (W)
T_b blood temperature in the sail (K)
T_c temperature of the core (K)
T_n temperature of the layer of fat around the core (K)

T_s surface temperature (K)
t_s skin and fat thickness of sail (m)
t_{s1} temperature of one side of the sail (K)
t_{s2} temperature of other side of the sail (K)
T_s = T_{s1} or T_{s2}, temperature of one side of the sail (K)
T_s^t temperature of one side of the sail at time t (K)
$T_s^{t+\Delta t}$ new temperature of one side of the sail at time t+Δ t (K)
T_∞ air temperature, temperature of the free stream fluid (K)
U wind velocity (m/s)
V_m volume of layer m (m^3)

Greek

$\frac{\Delta T}{\Delta t}$ change of temperature over a time period Δt (K/s)
ρ_f density of fat (=920 kg/m^3)

REFERENCES:

Bakker R.,1988. *The Dinosaur heresies,* Penguin Books.

Beckman W. A., Mitchell, J.W. and Porter, W. P.,1971. Thermal model for prediction of a desert iguana's daily and seasonal behavior. *Am. Soc. of Mech. Engineers Publ.* 71-W A/HT-35.

Bennett A.F. and Dawson R.W., 1976. Metabolism. In: Gans, C. (Ed.) *Biology of the Reptilia,* Vol. %. Academic Press: London, pp. 127-223.

Bogert M. C., 1959. How reptiles regulate their body temperature, *Scientific American,* No.200, pp. 105-120.

Duffie J. A. and Beckman W.A. 1991. *Solar engineering of thermal processes.* John Wiley & Sons. New York.

Haack S. C., 1986. A thermal model of the sailback pelycosaur. *Paloebiology* Vol. 12(4). pp.450-458.

McGowan C. ,1991. *Dinosaurs, spitfires & sea dragons,* Harvard University Press.

Mills A.F.1995. *Basic heat and mass transfer.* Richard D. Irwin. Chicago.

Mitchell, J. W., 1976. Heat transfer from spheres and other animal forms. *Biophysical Journal,* Vol. 16, 561

Romer S. A. & Price W. L.,1940. *Review of the Pelycosauria*, Geological Society of America Special papers No.28.

Spotila J.R., Soule O. H. and Gates D. M. 1972. The biophysical ecology of the alligator: Heat energy budgets and climate spaces. *Ecology*, Vol.53, No. 6. pp. 1094 -1102.

COST EFFECTIVENESS OF SOLAR HOUSE HEATING IN CYPRUS

Dr I. Michaelides, BSc (Hons), PGDipl, PhD, CEng MInstE
Senior Lecturer, Department of Mechanical Engineering, HTI.

ABSTRACT

This paper aims to investigate the cost effectiveness of solar house heating in Cyprus and is concerned with the optimisation of some design criteria for water based active solar heating systems. For this purpose, a system model based on the TRNSYS simulation programme has been used to correlate the performance and cost effectiveness of the system with a number of key design criteria.

Three design criteria are investigated in the present study, namely the collector slope (,), the collector to floor area criterion (CAF), which relates the collector area to the building floor area, and the collector to load criterion (CAL) which relates the collector area to the building thermal load.

The simulation results showed that the system is not viable when compared with a diesel oil alternative. The system is cost effective when compared with electricity. In that case the system solar fraction is maximised for CAF value of 0.3 m^2 of solar collector per m^2 of building floor area while the optimum CAL value is about 0.5 m^2 of collector per annual GJ of building thermal load. The system performance is maximum for a collector slope of 50±10° from horizontal.

INTRODUCTION

The sizing of a solar space heating system (SSH) for a building is a complex problem involving a number of interrelated factors and parameters which include, among others, the building thermal characteristics, the collector size and slope, the storage tank size, the heat exchangers size, the solar radiation, and a good number of economic parameters. The components of a SSH system must be well selected, properly sized, and carefully assembled in order to ensure that the system will function properly and cost-effectively. Oversizing of the system is not advisable because of high initial cost, while undersizing may not provide significant savings of conventional fuels. The optimisation of the design factors can be achieved either through experimental investigations which, however, are time consuming, expensive and not repeatable, or through modelling and simulations which can provide much of the same thermal performance information as physical experiments with less time, effort and expense.

Lunde (1979) correlated the performance of solar heating systems with the ratio of the collector area to the heating load (m^2/GJ). He simulated the performance of a solar heating system under the weather conditions of six different locations in the United States, at collector to load ratios ranging from 0 to 1.32 m^2/GJ. He demonstrated that this ratio is a good design parameter for predicting the performance of a solar heating system but he did not investigate the optimum design values for such applications.

Barley (1979) derived an algorithm for choosing insulation levels, as well as solar collection area, so as to minimize the overall cost of constructing and heating a building. The general algorithm is applicable with any solar performance prediction method and with economic criteria where the cost is a linear function of collection area and of auxiliary energy consumption. It has been shown that the ratio of solar collector area to the annual space heating load has an economically optimal value, corresponding to an optimal solar heating fraction, which is independent of the magnitude of the load.

The present study is dealt with the optimisation of three design criteria for solar space heating systems intended for residential houses in Cyprus, using the TRNSYS (Klein S.A. *et al.,* 1990) Simulation Programme. These are the collector slope, ,, the collector to floor area criterion, CAF, defined as the ratio of the collector area A_c to the floor area A_f of the building heated rooms, and the collector to load criterion, CAL, which is defined as the ratio of the collector surface area A_c to the annual space heating load. The CAF criterion is expressed in m^2 of collector per m^2 of floor area, and CAL is expressed in m^2 of collector per annual GJ of heating load.

DESCRIPTION OF THE SYSTEM

The schematic diagram of the solar heating system under investigation is illustrated in fig. 1. It is a water-based active system which comprises a number of flat-plate solar collectors coupled to a water storage tank. In addition, there is a load heat exchanger and two circulating pumps which are used to maintain the required water flow rate through the collector-storage and the storage-load heat exchanger sub-circuits. Auxiliary heating is provided by using conventional heaters to supply any shortfall in the heat energy that is supplied by the storage.

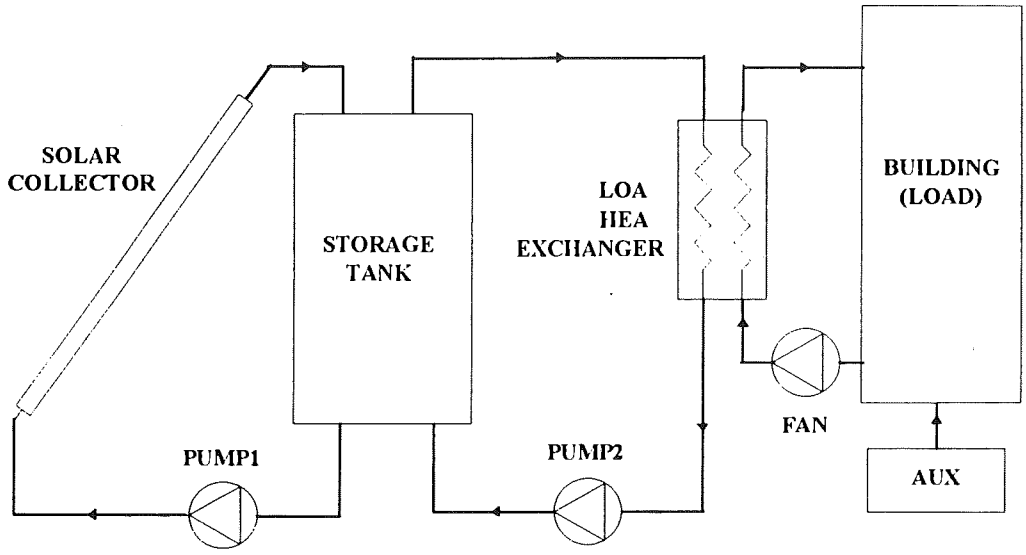

Fig. 1. Schematic diagram of the solar space heating system

Two scenarios are investigated, the first one assuming diesel oil as backup energy source, and the second one with electricity as backup energy source. The above approach has been adopted for the present study because there is a significant difference in the cost of energy provided by the said sources (see Table 2).

THE SIMULATION MODEL

According to Klein *et al.* (1990), there are three possibilities for modelling the building energy loads with TRNSYS. However, for relatively quick estimates of heating requirements, the space heating load model of TRNSYS known as Energy/(degree-day) TYPE 12 model, may be used. In this case, the building is modelled through the use of a single conductance (UA) for heat loss. A single energy balance on the structure is performed each simulation timestep.

The energy/(degree-day) concept has been shown by ASHRAE (1981) to be useful in estimating the monthly heating load of a structure. In this space heating load model, the energy/(degree-day), or more appropriately the energy/(degree-hour), concept is extended to estimate the hour by hour heating load of a structure. According to Klein *et al* (1990), the hour by hour space heating load estimated in this manner may be significantly in error, but over a period of time, the model may provide reasonable estimates of overall energy quantities. Furthermore, the model does provide an estimation of the space heating load with minimal computational effort.

The simulation of the system requires hourly weather data, representative of the location under investigation. In the absence of TMY for Cyprus, the monthly average values of the daily solar radiation and air temperatures for the years 1984-1987, have been used in the simulation. The TRNSYS programme, through its Weather Data Generator has the capability of producing hourly data from monthly averages.

Given a certain load that is some function of time through a year, a type of collector and a system configuration, the primary design variable is the collector size. System performance is much more sensitive to collector area than to any other variable (Duffie and Beckman, 1980). To this effect the economics of the system are very essential and need to be treated in conjunction with the thermal performance of the system. For this purpose, the Economic Analysis subroutine of TRNSYS has been included in the system model.

The performance of the system will be expressed in terms of its solar fraction, f, which is defined as the fraction of the space heating load provided by solar energy and can be calculated from the following relationship:

$$f = \frac{Q_{load} - Q_{aux}}{Q_{load}}$$

where Q_{load} is the space heating load and Q_{aux} is the auxiliary energy supplied to the system.

The costs of solar heating equipment include purchase and installation of all collectors, storage tank, pumps, controls, ductwork, piping, heat exchangers, etc., and are considered as the incremental costs, that is, the difference in cost between the solar heating system and a conventional heating system.

Operating costs include costs of auxiliary energy, parasitic power, maintenance, etc. It is assumed that the costs of components which are common to both, conventional and solar heating systems, e.g. the furnace, load heat exchanger, ductwork, fans, controls, and the maintenance costs of this equipment are identical. As a result of the above, all references to solar heating system costs, or conventional system costs, refer to the cost increment above the common costs.

For the simulations of the present study, it has been necessary to use a number of parameters which concern the building, the solar system and the economic scenario, some of which are listed in Tables 1 and 2.

Table 1. System simulation parameters

Parameter	Value *
$F_R U_L$	24.4 kJ h^{-1} K^{-1} m^{-2}
$F_R(\alpha\tau)_n$	0.78
G	50 kg h^{-1} m^{-2}
G_{test}	54 kg h^{-1} m^{-2}
U_s	1.2 kJ h^{-1} K^{-1} m^{-2}
UA (building)	4000 kJ h^{-1} K^{-1}
β	50° from horizontal
$\varepsilon_L C_{min}/UA$	2
* Taken from experimental tests	

Table 2. Economic parameters

Parameter	Value	Parameter	Value
C_{EE}	18 CYP/GJ	d	9%
C_{ED}	3.7 CYP/GJ	M_s	1%
N_E	20 yrs	i	5%
D	50%	t	9%
m	9%	N_D	20 yrs
N_L	15 yrs	i_{FCF}	5%
DEG	1%/yr	i_{FBUP}	5%/yr

One of the parameters which concern the building is the dimensionless parameter $\hat{A}_L C_{min}/UA$, where $\hat{A}_L$ is the effectiveness of the load heat exchanger, C_{min} is the minimum capacitance rate of the heat exchanger and UA is the total building energy loss coefficient. This parameter has been found to provide a measure of the size of the heat exchanger needed to supply solar energy to a specified building (Klein *et al.* 1976). Klein et al. suggest that reasonable values of $\hat{A}_L C_{min}/UA$ for solar space heating systems are between 1 and 3. Based on the above and the findings of Michaelides (1993), in the present study $\hat{A}_L C_{min}/UA$ is taken as 2.

ANALYSIS OF SIMULATION RESULTS

A number of simulations were run on a yearly basis to investigate the optimum collector slope for the system. These results were used to plot the graph of fig.2 which shows the variation of the annual solar fraction of the system with the collector tilt angle. It is evident from this figure that the system performance is maximised when the collector tilt angle is 48° from horizontal. This is in excellent agreement with the results of Lof and Tybout (1974). However, there is a range of values from 40° to 55° which brings about maximum performance. This is because at tilt angles between 40° and 55° the incident solar radiation falls on the collector almost perpendicularly, therefore minimising the reflected and maximising the transmitted solar radiation components. As the collector slope decreases below 30° or increases above 70° from horizontal, there is a drastic reduction in the solar contribution. This is attributed to the fact that the angle of incidence deviates from the normal direction of the collector surface resulting in higher reflection of solar radiation. It is therefore a suggested that a collector slope of 50±10° from horizontal is a good design practice for Cyprus.

For the simulations of the present study, the collector slope is assummed to be 50° from horizontal. A number of simulations were run for different collector areas, assuming a storage factor of 50 l/m^2 and a water flow rate through the collector equal to 50 kg/h per m^2 of collector. The results of the simulations were used to plot graphs relating the annual solar fraction and the life cycle savings of the system to the design criteria CAF and CAL. These are shown in figs. 3 and 4. This approach is considered useful because it offers the flexibility to the designer to base his design on either of the parameters and do some kind of cross-checking in determining the optimum collector area of a solar space heating system.

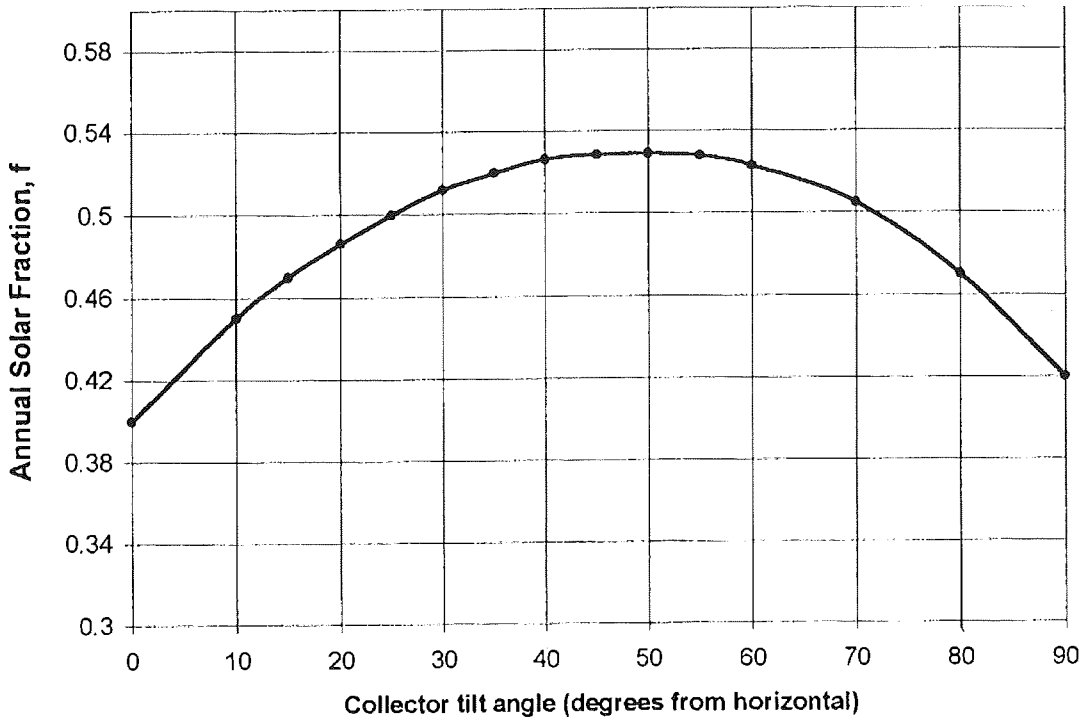

Fig. 2. Optimisaton of collector tilt angle

It is seen from the graphs that the system solar fraction, f, which is an indication of the what proportion of the building thermal load is met by solar, increases with an increase in both the CAF and the CAL criteria. The increase is more dinstict at low values, but the rate of increase is reduced as CAF and CAL increase to higher values. This can be explained by the fact that an increase in the collector area will result to higher temperatures in the collector system, thus increased heat losses which in effect will bring about lower collector efficiencies and therefore reduced contribution to the building heating load.

The situation is not the same for the life cycle savings. In the case of diesel oil backup it is seen that as the CAF criterion increases, the LCS decrease. It is interesting to note that for CAF values up to 0.1 the LCS are positive while for CAF higher than 0.1 the LCS get negative. At the same time, it is seen from the simulation results that the payback period varies from 9 years to values which exceed the expected lifetime of the system, i.e. higher than 20 years (see Table 3). It is, therefore, evident that solar space heating in Cyprus, under the socio-economic and weather conditions prevailing in the island, is not cost effective and in fact cannot compete with conventional heating systems which use diesel oil fired boilers.

The situation is however different if the comparison is made with electricity. The life cycle savings are positive for the ranges of CAF and CAL values investigated in this study and much higher than those experienced in the case of diesel oil. At low values of CAF and CAL, the life cycle savings are low; as CAF and CAL increase, the life cycle savings increase until they reach a maximum value corresponding to approximately 0.3 m^2/GJ and then declines to reach a value lower than that corresponding to the low values of CAF and CAL. Therefore, the optimum value for the CAF criterion is 0.3 m^2 of collector per m^2 of building floor area but any value within the range of 0.25 and 0.4 seem to represent optimal design values.

In the same way, from fig. 4 it is found that the life cycle savings maximise at a CAL value of approximately 0.5 m^2/GJ but it is also remarkable that any value within the range of 0.4 and 0.7 m^2/GJ would represent optimal design values.

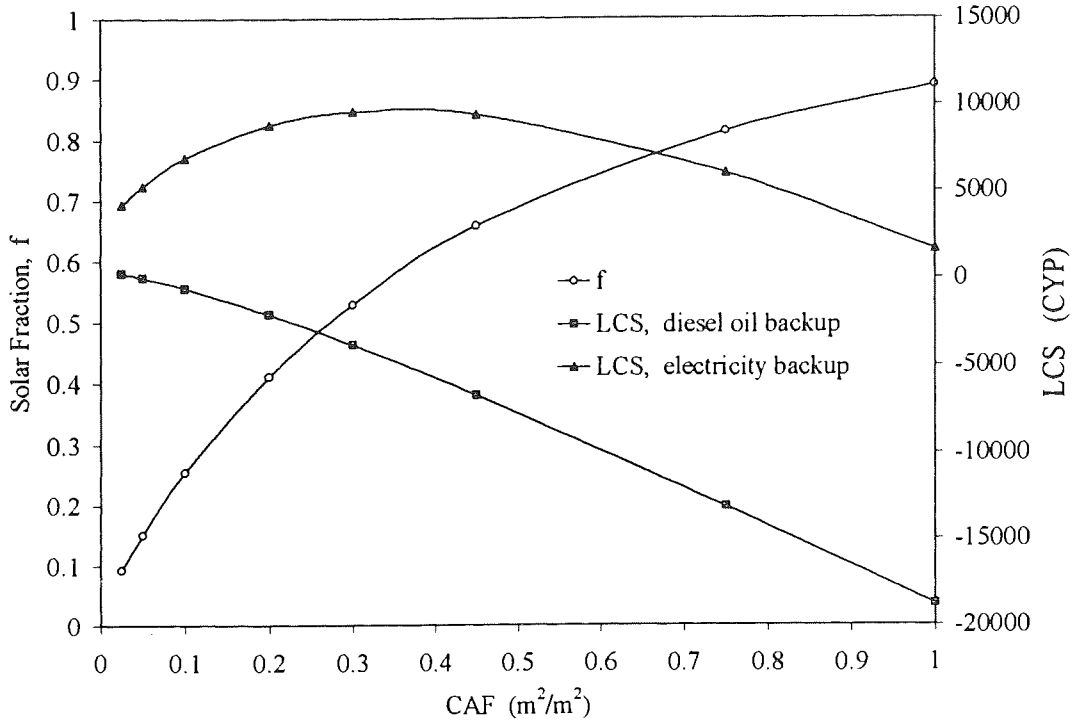

Fig. 3. Annual solar fraction and life cycle savings as a function of the collector to building floor area criterion (CAF).

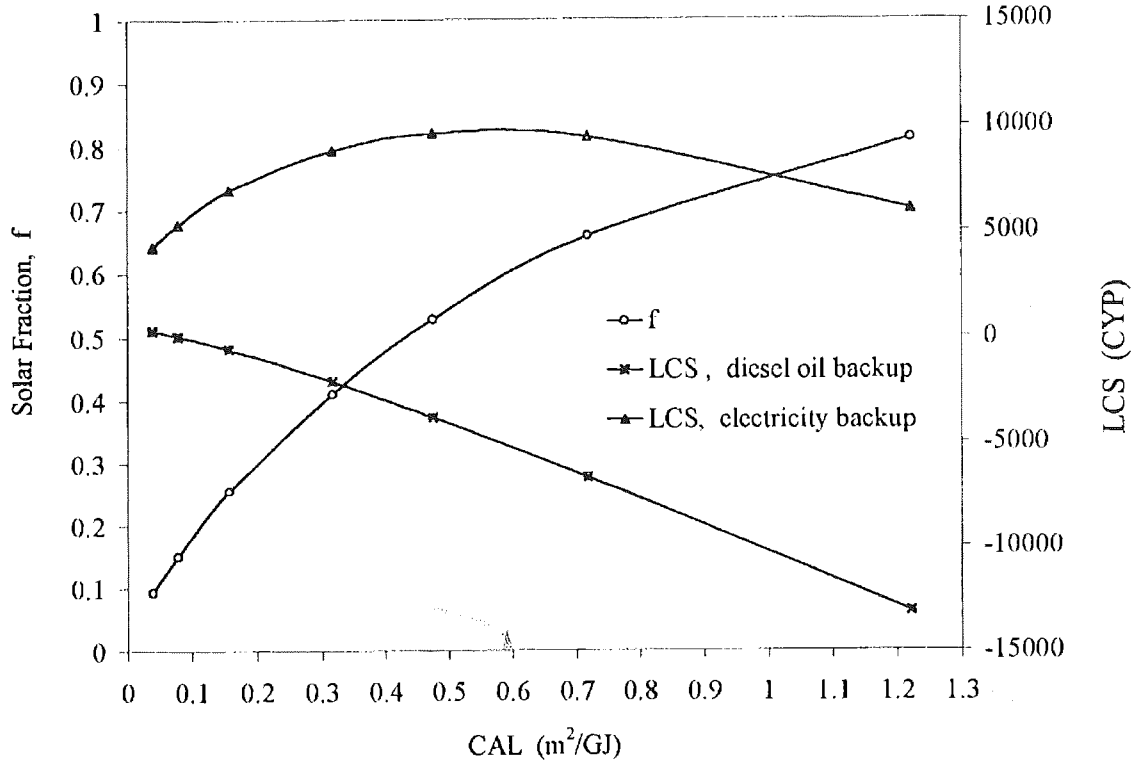

Fig. 4. Annual solar fraction and life cycle savings as a function of the collector to building thermal load criterion (CAL).

The situation is however different if the comparison is made with electricity. The life cycle savings are positive for the ranges of CAF and CAL values investigated in this study and much higher than those experienced in the case of diesel oil. At low values of CAF and CAL, the life cycle savings are low; as CAF and CAL increase, the life cycle savings increase until they reach a maximum value corresponding to approximately 0.3 m^2/GJ and then declines to reach a value lower than that corresponding to the low values of CAF and CAL. Therefore, the optimum value for

the CAF criterion is 0.3 m^2 of collector per m^2 of building floor area but any value within the range of 0.25 and 0.4 seem to represent optimal design values.

In the same way, from fig. 3 it is found that the life cycle savings maximise at a CAL value of approximately 0.5 m2/GJ but it is also remarkable that any value within the range of 0.4 and 0.7 m^2/GJ would represent optimal design values.

At optimal values of CAF and CAL criteria, the solar fraction is approximately 0.53, which means that 53% of the space heating load of the building is met by solar while the rest is supplied by the auxiliary heating unit. Simulation results revealed that under the above optimal conditions, the payback period for the solar system is around 5 years which is a very attractive figure.

The curves of figs. 3 and 4 could be used for the prediction of the annual solar fraction of a solar space heating system at any imposed collector size. They can also serve as a quick estimate of the expected yearly contribution of a solar heating system to the building's heating requirements.

Table 3. Payback period and system solar fraction for diesel oil and electricity backup

CAF (m^2/m^2)	Diesel oil backup		Electricity backup	
	f	Payback (years)	f	Payback (years)
0.025	0.093	9	0.093	3
0.050	0.151	11	0.151	4
0.100	0.255	13	0.255	4
0.200	0.410	15	0.410	5
0.300	0.528	17	0.528	5
0.450	0.658	20	0.658	6
0.750	0.812	>20	0.812	8
1.000	0.888	>20	0.888	10

CONCLUSIONS

It has been found that solar space heating in Cyprus, under the socio-economic and weather conditions prevailing in the island, is not cost effective and in fact cannot compete with conventional heating systems which use diesel oil fired boilers.

The situation is different if electricity is the competitor. In such a case, a designer could use either the CAF criterion or the CAL criterion to size the solar heating system. Solar heating is cost effective for a size of 0.3 m^2 of collector per m^2 of building floor area. For a cross check calculation, the designer could use the CAL criterion which is 0.5 m^2 of collector per GJ of building heating load. The above criteria are valid for ground floor residential houses in Cyprus.

The optimum collector slope was found to be around 48° from horizontal, which is the location altitude (35°) increased by 13°. For a deviation of ±10° from the optimum the annual solar fraction does not change considerably but outside this range the system performance falls rapidly. For design purposes in Cyprus it is suggested that a collector slope of 50±10° from horizontal will result to optimum performance.

REFERENCES

ASHRAE, 1981. *Handbook of Fundamentals.* New York: American Society of Heating Refrigeration and Air conditioning Engineers.

Barley, C.D. 1979. Load optimisation in solar space heating systems. *Solar Energy* **23,** 149-156.

Duffie, J.A. and Beckman, W.A, 1980. *Solar Engineering of Thermal Processes.* John Wiley, New York.

Klein, S.A., Beckman, W.A., and Duffie, J.A., 1976. A design procedure for solar heating systems. *Solar Energy* **18,** 113-127.

Klein, S.A. et al. 1990. *TRNSYS, a Transient Simulation Program. Solar Energy Laboratory,* University of Wisconsin.

Lof G.O.G. and Tybout R.A., 1974. Design and Cost of Optimal Systems for Residential Heating and cooling by Solar energy. *Solar Energy* 16, 9-18.

Lunde, P.J., 1979. Prediction of the performance of solar heating systems over a range of storage capacities. *Solar Energy* 23, 115-121.

Michaelides, I.M, 1993. Computer simulation and optimisation of solar heating systems for Cyprus. PhD thesis, University of Westminster, London, UK.

NOMENCLATURE

A_c	Collector area, m^2
A_f	Building floor area, m^2
CAF	Collector to floor area factor, m^2 of collector per m2 floor area
CAL	Collector to load factor, m^2 per annual GJ
C_{EE}	Cost of electric energy, CYP/GJ
C_{ED}	Cost of diesel oil energy, CYP/GJ
C_{min}	Minimum capacitance rate in a heat exchanger, kJ h^{-1} K^{-1}
CYP	Cyprus Pound
d	Market discount rate, %
D	Down payment, % of original investment
DEG	Thermal performance degradation, %/yr
f	Solar fraction (fraction of the load that is met by solar)
F_RU_L	Slope of the collector efficiency curve, kJ h-1K-1 m-2
$F_R(\alpha\tau)_n$	Intercept of the collector efficiency curve
G	Collector mass flux, kg h^{-1} m^{-2}
G_{test}	Collector mass flux at test conditions, kg h^{-1} m^{-2}
i	Inflation rate, %
i_{FBUP}	Backup (auxiliary) fuel inflation rate, %
i_{FCF}	Conventional fuel inflation rate, %
m	Mortgage, %/yr
M_S	Extra insurance, maintenance in year 1, % of initial investment
N_D	Useful life for depreciation purposes, yrs
N_E	Period of economic analysis, yrs
N_L	Term of loan, yrs
Q_{aux}	Auxiliary energy, kJ
Q_{load}	Space heating load, kJ
t	Effective income tax rate (%), time
U_L	Collector heat loss coefficient, kJ h^{-1} K^{-1} m^{-2}
U_s	Heat loss coefficient of storage tank, kJ h^{-1} K^{-1} m^{-2}
UA	Constant characterising the building, kJ h^{-1} K^{-1}
β	Collector tilt angle, degrees from horizontal
ε_L	Effectiveness of the space heating load heat exchanger.

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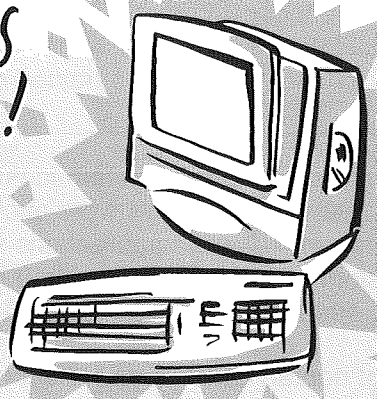

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AN ALTERNATIVE METHOD FOR CALCULATING THE OVERALL HEAT TRANSFER COEFFICIENT

Dr Soteris Kalogirou, M.Phil, PhD, Eur Ing, C.Eng. MCIBSE, MASHRAE, MISES, Laboratory Assistant, Department of Mechanical Engineering, HTI.
Constantinos Neocleous, B.E., M.Sc., Senior Lecturer, Department of Mechanical Engineering, HTI.

ABSTRACT

An important parameter for the estimation of building thermal loads is the overall heat transfer coefficient (U-value). An accurate value will enable a more correct estimation of the thermal load. Neural networks are widely accepted as a technology offering an alternative way to tackle complex and ill specified problems. They can learn from examples, are fault tolerant in the sense that they are able to handle noisy and incomplete data, are able to deal with non-linear problems, and once trained can perform prediction and generalisation at high speed. Artificial neural networks have been used in diverse applications in control, forecasting, power systems, and many other non-engineering applications. The objective of this study is to investigate the suitability of artificial neural networks as tools for the estimation of U-values quickly and accurately. The data presented as input to the network were the thicknesses of hollow and solid bricks and concrete, of various types of insulating materials and air gap, and a class value specifying whether plaster is applied on both sides or on one side of the wall, and on whether plaster is not used. The network output is the U-value calculated from well established procedures. The statistical R^2-value for the training data set was equal to 0.9982. After training, the network learns the basic mechanics of calculation, and thus is able to generalise to an unknown set of data. Unknown data, i.e., constructions with material thicknesses not known to the network, were subsequently used to investigate the accuracy of the prediction. Predictions with R^2-value equal to 0.9989 and a maximum error confined to less than 1.4% for the test set were obtained. This is considered satisfactory for design purposes. Although estimated U-values have been used in this work, if experimental values are available these will enhance the capability of the method, as the prediction will not depend on published data but on experimental values. It should be noted that in this case it would not be required to perform experiments with all possible thicknesses of materials but only a limited number for each different material.

1. INTRODUCTION

The overall heat transfer coefficient (U-value) is defined as the thermal transmission through unit areas of a particular body or assembly, including surface films where the difference between the fluid temperatures on either side of the body or assembly is unity (ASHRAE, 1989).

For the estimation of the U-value it is required to find from reliable sources the resistance values of all the constituent components that make a construction, add them together and then calculate the inverse. This is a time consuming process that needs to be repeated very often especially nowadays that a large variety of constructions are used by the building industry.

Neural networks are widely accepted as a technology offering an alternative way to tackle complex and ill specified problems. They can learn from examples, are fault tolerant in the sense that they are able to handle noisy and incomplete data, are able to deal with non-linear problems, and once trained can perform prediction and generalization at very high speed.

The power of neural networks in modeling complex mappings and in system identification has been demonstrated (Kohonen, 1984; Narendra & Parthasarathi, 1990; Ito, 1992). This work encouraged many researchers to explore the possibility of using neural network models in real world applications such as in control systems, in classification, and modeling complex process transformations (Curtiss et al., 1995; Kah et al., 1995; Kreider & Wang, 1995; Pattichis et al., 1995; Kalogirou et al., 1996a, 1996b and 1997).

The aim of this study is to investigate the suitability of neural networks as tools for the estimation of U-values given the various thicknesses of materials. This will facilitate the work of design engineers in the field.

2. DESCRIPTION OF THE METHOD

The data needed for the training of the network need first to be collected and tabulated in such a way so as to represent the independent (inputs) and the dependent (output) parameters. For this study only wall constructions are presented since the primary objective is to investigate the suitability of the method for such predictions. The combination of materials required are given in Table 1 together with a sample of cases. A total of 71 such combinations were used. Film coefficients have not been used since these are implicitly considered in the U-values (output). Materials which are not employed in a particular construction are given a thickness equal to zero.

The values used for training the network are modified as shown in Table 2, i.e., no actual values are used for the materials with small effect on the U-value. The values for bricks and concrete have been divided by 100 whereas for the plaster a value 2 is used if plaster is used on both sides of the wall, 1 if plaster is used on only one surface, and 0 if no plaster is used. The thicknesses of insulating materials and air gap are used as indicated in Table 1. The reason for these modifications is that the relatively high thicknesses of bricks, concrete and plaster, as compared to those of the insulating materials and air gap, drive the network to wrong correlations as to the type of material the U-value mainly depends and hence prevents it from learning fast.

The input parameters used for each pattern is a set of values corresponding to the material thicknesses as explained above. The output is the U-value. It should be noted that the U-value used included the air film resistances and therefore these values were not explicitly included into the input parameters supplied to the network.

Table 1. Combinations of materials used for training the ANN

Independent variables (thickness in mm)							Dependent variable
Hollow Brick	Solid Brick	Concrete	Polystyrene	Polyurethane	Air	Plaster	U-value (W/m^2 K)
200	0	0	0	0	0	30	1.92
200	0	0	0	0	50	30	1.49
100	100	0	0	0	0	15	1.96
100	0	100	20	0	30	15	0.81
0	100	150	30	0	20	15	0.71
200	0	0	50	0	0	30	0.52
...	...	...	...	...	...	...	.....

Table 2. Range of material thicknesses and values used for training the network

Material	Thickness (mm)	Value used in network
Hollow and solid bricks and concrete	200 150 100 0	2 1.5 1 0
Plaster	30 15 0	2 1 0
Polystyrene, polyurethane and air gap	50 30 25 20 0	thickness in (mm)

A number of networks of different structures, sizes and learning parameters have been tried. The architecture that was ultimately selected is shown in Fig. 1. It is composed of five slabs, three of which are hidden. The activation function used for each slab is also shown in the figure. Seven element inputs have been used corresponding to the values of the input parameters listed above. The learning procedure was implemented by using the backpropagation algorithm. The learning rate was set to a constant value of 0.5 and the momentum factor to 0.7. The weights were initialised to a value of 0.3. From a total of 71 patterns, 7 were randomly selected to be used as test patterns and the remaining 64 were used for training the network. For the training data set an R^2 value of 0.9982 was obtained.

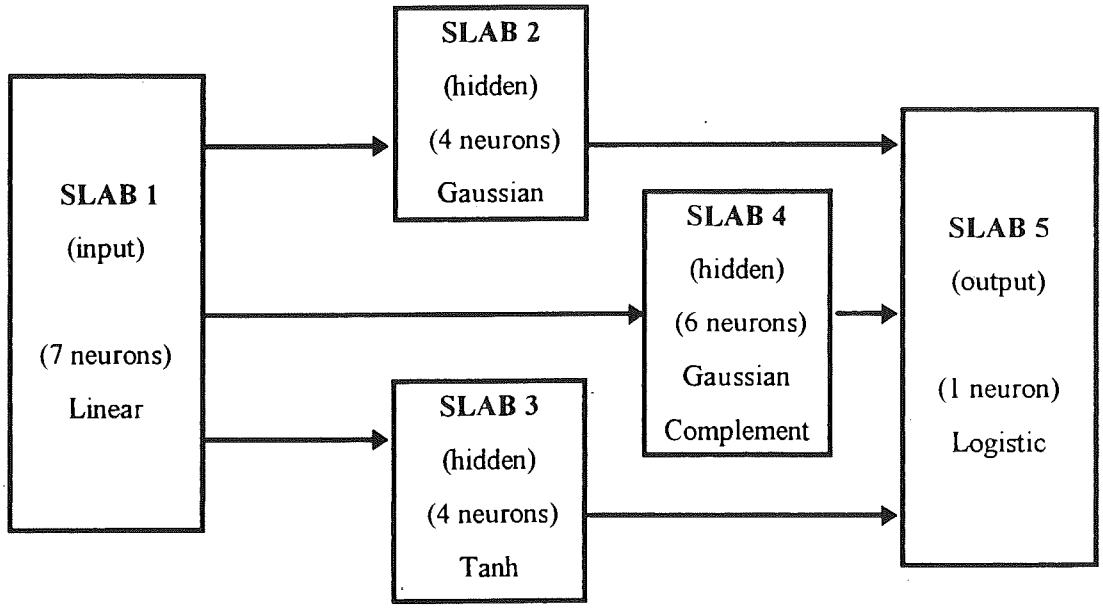


Fig. 1. The selected neural network architecture

The trained network was subsequently used to predict the U-value of various constructions the characteristics of which are shown in Table 3. These constructions were completely unknown to the network. The U-values were predicted with an R^2 value equal to 0.9989 which is considered satisfactory for design purposes. A comparison of the predicted and actual results is shown in Table 4 where the maximum percentage error for each case is shown. It can be seen from Table 4 that the maximum error is confined to less than 1.4% (0.02 W/m^{2}K) which is considered a small deviation for design purposes. Although estimated U-values have been used in this work, if experimental values are available these will enhance the capability of the method, as the prediction will not depend on handbook recorded data but on real values. This is useful for countries where local building material thermal properties are not accurately known and values obtained from published references are not always valid for materials used locally. It should be noted that in this case it would not be required to perform experiments with all possible thicknesses of materials but only a limited number for each different type of material.

Table 3. Constructions used for testing the network

Independent variables (thickness in mm)							Dependent variable
Hollow Brick	Solid Brick	Concrete	Polystyrene	Polyurethane	Air	Plaster	U-value (W/m^2 K)
100	100	0	25	0	25	15	0.73
100	100	0	0	0	30	15	1.49
100	0	100	25	0	25	15	0.73
100	0	100	0	25	25	15	0.59
200	0	0	25	0	25	30	0.72
200	0	0	0	25	0	30	0.65

Table 4. Comparison of the actual and predicted U-values

Actual U-value	Predicted U-value	Difference	% error
0.73	0.72	0.01	1.4
1.49	1.51	0.2	1.3
0.73	0.73	0	0.0
0.59	0.59	0	0.0
0.72	0.72	0	0.0
0.65	0.65	0	0.0

3. CONCLUSIONS

An easy and quick method is presented in this paper for the estimation of U-values. This is believed to facilitate the work of design engineers in the field. The method is particularly important in cases where the resistance value of a material is not included in a handbook. In this case experiments need to be set up in order to measure the conductivity of the material. In this case not all possible variations should be covered as the network is able to generalize and give predictions with a minimum of data. In the future we are planning to use the method to propose new and possibly more effective material compositions at low cost.

REFERENCES

ASHRAE (1989). *Handbook of Fundamentals.*

Curtiss P.S., Brandemuehl, M.J. and Kreider J.F. (1995). Energy Management in Central HVAC Plants using Neural Networks. In Haberl J.S., Nelson R.M. and Culp C.C. (Eds.). *The use of Artificial Intelligence in Building Systems.* ASHRAE. pp. 199-216.

Ito Y. (1992). Approximation of Functions on a Compact Set by Finite Sums of a Sigmoid Function With and Without Scaling. *Neural Networks,* Vol. 4, pp. 817-826.

Kah, A.H., San, Q.Y., Guan, S.C., Kiat, W.C. and Koh, Y.C. (1995). Smart Air-Conditioning System Using Multilayer Perceptron Neural Network with a Modular Approach. *Proceedings of the IEEE International Conference ICNN'95,* Perth, Western Australia, Vol. 5, pp. 2314-2319.

Kalogirou S.A., Neocleous C.C and Schizas C.N. (1996a). A Comparative Study of Methods for Estimating Intercept Factor of Parabolic Trough Collectors. *Proceedings of the International Conference EANN'96,* London, UK, pp. 5-8.

Kalogirou S.A., Neocleous C.C and Schizas C.N. (1996b). Artificial Neural Networks in Modeling the Heat-up Response of a Solar Steam Generation Plant. *Proceedings of the International Conference EANN'96,* London, UK, pp. 1-4.

Kalogirou S.A., Neocleous C.C and Schizas C.N. (1997). Heating Load Estimation Using Artificial Neural Networks. *Proceedings of the CLIMA 2000 Conference,* paper number P159, Brussels, Belgium.

Kohonen T. (1984). *Self-Organisation and Associative Memories.* Berlin-Verlag.

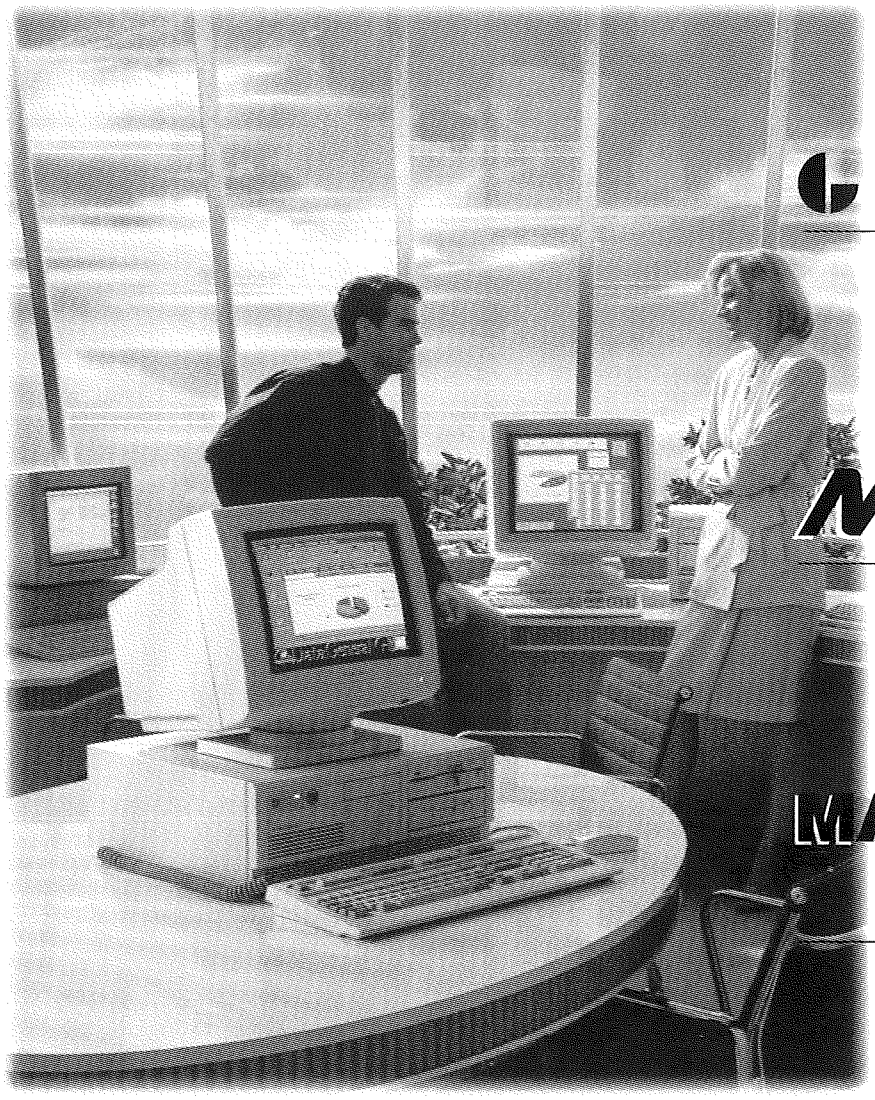
Kreider, J.F. and Wang, X.A. (1995). Artificial Neural Network Demonstration for Automated Generation of Energy Use Predictors for Commercial Buildings. *The use of Artificial Intelligence in Building Systems.* ASHRAE. pp. 193-198.

Narendra K.S. & Parthasarathi K. (1990). Identification and Control of Dynamical Systems Using Neural Networks. *IEEE Transactions on Neural Networks,* Vol. 1, pp. 4-27.

Pattichis C.S., Schizas C.N. and Middleton L. (1995). Neural Networks Models in EMG diagnosis. *IEEE Transactions on Biomedical Engineering,* Vol. 42,5, pp. 1-11.

Rumelhart D.E., Hinton G.E. and Williams R.J. (1986). Learning Internal Representations by Error Propagation. *Parallel Distributed Processing: Explorations in the Microstructure of Cognition,* Vol. 1, Chapter 8, Cambridge, MA, MIT Press.

Werbos P.J. (1974). *Beyond Regression: New Tools for Prediction and Analysis in the behavioural Science,* PhD Thesis, Harvard University, Cambridge, MA.



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HAMMERSTEIN INTEGRAL EQUATIONS WITH EXPANDING MAPS IN HILBERT SPACES ·

Dr. A.G. Tamanas
Lecturer in Mathematics, H.T.I.

A nonlinear integral equation of Hammerstein type is an equation of the form

$$u(x) + \int_{\Omega} k(x,y)\, f(y, u(y))\, dy = v(x) \qquad (1)$$

where Ω is a measure space whose (Lebesgue) measure is denoted by dy, $k: \Omega \times \Omega \to R$ is a given function, the kernel of the integral equation, $f: \Omega \times \Omega \to R$ is another given function and the known function v and the unknown function u are defined on Ω and assumed to belong to a given class, such as $L(\Omega)$, of real valued functions.

We shall transform equation (1) into an abstract functional equation to which the methods of non-linear functional analysis could be applied. In fact nonlinear functional analysis found important applications to Hammerstein Integral equations, perhaps, second only to its applications to partial differential equations.

Now let X and Y be two classes of integrable functions defined on Ω. We introduce two operators $K: X \to Y$ and $F: Y \to X$ by requiring that

$$K(u)(x) = \int_{\Omega} K(x,y)\, u(y) dy$$

$(x \varepsilon \Omega,\ u \varepsilon X)$, and $F(v)(y) = f(y, u(y))$ $(y \varepsilon \Omega,\ v \varepsilon Y)$

and that are well defined and composed so that the product operator KF maps the space X into itself. The operator F is known as the Nemytskii operator. Then equation (I) can be written as:

$$u + KF(u) = v, \quad v \varepsilon X \qquad (2)$$

Usually the spaces X and $Y = X^*$, the dual of X , are taken as reflexive Banach spaces. In the present note we shall study (I) in a real Hilbert space, denoted by H.

Equations given by (1) were first studied using variational analytic methods by A.Hammerstein [1]. Advancements in the study of Hammerstein equations were made after the introduction of compact linear operators and linear integral equations,with compact operators, by F. Reisz and by the use of the Schauder - Leray degree theory. In the 60's and 70's Hammerstein integral equations were studied under the much less restrictive hypothesis of monotone type operators (F.E. Browder[2]).

The first type of monotone operators to be studied were the strongly monotone operators ([3], [4]) i.e. operators, F, satisfying a relation of the form

$$\langle Fu - Fv,\ u-v \rangle \geq a\ \|u-v\|^2 \qquad (3)$$

Where $u,v \varepsilon H$ and $a>0$. These operators are a natural generalisation of the well studied contraction maps and occur naturally in partial differential equations of elliptic type. Monotone operators are obtained if we let $a=0$

It is to be noted that a weaker condition than strong monotinicity is:

$$\|Fu - Fv\| \geq a\ \|u-v\| \qquad (4)$$

which defines the expanding maps on a Hilbert space with norm $\|.\|$.

Expanding maps have been introduced by L Nirenberg [5] in the following problem:

Suppose that $F:H \rightarrow H$ is a continuous bounded operator which is expanding.

Suppose the following two conditions are satisfied by F.

(ι) F maps a neighborhood of the origin onto a neighborhood of the origin.
(ii) $F(O) = O$
Is F surjective i.e. does F have all of H as its range ?

Note that, as is easily verified, a mapping $F:H \rightarrow H$ is monotone if and only if $I + t F$ is expanding for all $t>0$, where I is the identity mapping of H. In particular if F is strongly monotone then F is expanding. We, also note that condition (ii) asked by L. Nirenberg is necessary since the mapping $F: l^2 \rightarrow l^2$ defined by $Fx = (0, x_1, x_2, ...)$
for $x = (x_1, x_2, x_3, ...) \varepsilon H = l^2$ satisfies (ii) but it is certainly not surjective.

For the case F strongly monotone then conditions (i) and (ii) are satisfied since, as is well known, F is a homeomorphism of H onto H.

For a finite dimensional Euclidean space, H, F, is surjective, since under the stated conditions its range is closed and also, by the Riemann mapping theorem, open and hence its range is the whole space.

When F is assumed to be a Frechet differentiable mapping in a real Hilbert space, then under conditions (ι) and (ii) the range of F is all of H. This was first established in [6].

The above remarks contain all that is known about the surjectivity of expanding maps. The problem of L. Nirenberg in its full generality is still open.

No applications of expanding maps are still known. Here below we prove a new existence and uniqueness theorem for the abstract functional equation (2) using expanding maps.

Furthermore we give a constructive method enabling one to obtain the unique solution starting from any initial approximation.

Definition 1

(i) A nonlinear operator $F:H \to H$ is hemicontinuous if for any three elements u,v,w, of H
$t \to < F(u + t\,v), w >$

is continuous from H into R.

(ii) F is demicontinuous if it maps strongly convergent sequences in H into weakly convergent ones.

(iii) F is bounded if it maps bounded subsets of H into bounded subsets of H.

Note that continuous and demicontinuous operators are hemicontinuous.

THEOREM

Let H be a real Hilbert space. Let $K:H \to H$ be a (nonlinear) hemicontinuous, bounded mapping satisfying

(i) $<Ku - Kv, u-v> \geq c\,\|u-v\|^2$

with $c>1$, $u, v \in H$ and $K(0)=0$.

Let $F:H \to H$ be a surjective expanding map i.e.

(ii) $\|Fx-Fy\| > \|x-y\|$

(iii) $F(0)=0$

(iv) F is continuous and bounded.

Then the equation $x + KFx = y$ has a unique solution in H, for any $y \in H$.

Furthermore $(I + KF)^{-1}$ is continuous and bounded.
The sequence defined by:

$$x_{n+1} = y - F^{-1}\,K^{-1}(x_n)$$

converges strongly to the solution of $x + KFx = y$, for any initial approximation $x_0 \in H$.

Proof:

Under the hypotheses of the theorem on F we have that $F^{-1} : H \to H$, since F is surjective and injective, and F^{-1} is a bounded, contractive and so continuous mapping of H onto H.

We can therefore rewrite the equation $x + KFx = y$ into the equivalent from $F^{-1}(v) + Kv = y$, with $v=Fx$.

Let $T = F^{-1} + K$, then T is single valued and everywhere defined on H. Since F^{-1} and K are bounded so is their sum T. Next we claim that T is strongly monotone and hemi-continuous.

Let u and v be two arbitrary elements of H, then we have that:

$$\langle Tu-Tv, u-v\rangle = \langle F^{-1} u-F^{-1} v, u-v\rangle + \langle Ku-Kv, u-v\rangle$$

$$\geq c\,\|u-v\|^2 - \|F^{-1} u-F^{-1} v\|\,\|u-v\|$$

$$\geq (c-1)\,.\|u-v\|^2$$

Since $c>1$ we have established the strong monotonicity of T. Since K is hemi-continuous and F^{-1} continuous it follows that T is hemi-continuous. By a well known result on monotone operators it follows that T is surjective and that the solution is also unique.

That $(I+ KF)^{-1}$ is continuous bounded follows from the fact that

$$\|(I+KF)^{-1} u - (I+KF)^{-1} v\| \leq 1/(1-c)\,\|u-v\|$$

To see that this last inequality is true let

$x+KFx=u$ and

$y+KFy = v$

Then taking the inner product in the form
$\langle x-y, Fx-Fy\rangle + \langle KFx-KFy, Fx-Fy\rangle = \langle u-v, Fx-Fy\rangle$

Using now the properties of K and F we have that
$-\|Fx-Fy\|\,\|x-y\| + c\|Fx-Fy\|^2$
$\leq \|u-v\|\,\|Fx-Fy\|$

Therefore:
$-\|x-y\| + c\|Fx-Fy\| \leq \|u-v\|$

And since F is expanding we obtain that
$(c-1)\,\|x-y\| \leq \|u-v\|$

Thus $(I+KF)^{-1}$ is non-expanding and so continuous and bounded.

To show that the sequence given in the theorem converges strongly to the solution, let $x_o \varepsilon H$, be any point of the Hilbert space H. Then

$$x_{n-1} = y-F^{-1} K^{-1} (x_n)$$

$$x_n = y-F^{-1} K^{-1} (x_{n-1}) \text{ and so}$$

$$x_{n-1} - x_n = F^{-1} K^{-1} x_{n-1} - F^{-1} K^{-1} x_n$$

Taking the norm of both sides:

$$\begin{aligned} \|x_{n+1} - x_n\| &= \|F^{-1} K^{-1} x_{n-1} - F^{-1} K^{-1} x_n\| \\ &\leq \|K x_{n-1} - K x_n\| \\ &\leq (1/c) \|x_n - x_{n-1}\| \\ &\leq (1/c)(n-1) \|x_1 - x_o\| \end{aligned}$$

Therefore for $n \geq 1$, $p \geq 1$

$$\|x_{n+p} - x_n\| \leq \|x_{n+p} - x_{n+p-1}) + \ldots\ldots + \| (x_{n+1} - x_n)\|$$

$$\leq a^{n-1} (a^{p-1} + \ldots\ldots + 1) \|x_1 - x_o\|$$

$$\leq a^{n-1} (1-a^p)/\{1-a) \|x_1 - x_o\|$$

where $a = 1/c < 1$.

Taking the limit as $n \to +\infty$, $\|x_{n+p} - x_y\| \to 0$,
strongly and it is therefore a Cauchy sequence in a Hilbert space and so strongly convergent. Thus the proof is complete.

REMARKS

(i) If K is linear strongly monotone then the theorem is still true.

(ii) The theorem remains true if instead of a real Hilbert space we consider a real reflexive Banach space X and its dual X* and if we replace the inner product of H with the duality pairing of the Banach spaces.

REFERENCES

1. Hammerstein, A, Nichlineare Integralgleichungen nebst Anwendungen. Act Math., 54, (1930), 117-176.

2. Browder, F.E., Nonlinear Functional Analysis and Nonlinear Integral Equations of Hammerstein and Urysohn type, in E.H. Zarantonello (Ed), Contributions to Nonlinear Functional, Academic Press, 1971.

3. Browder F.E., The Solvability of Nonlinear Functional Equations Duke Math. J. (30), 1963, 557-566.

4. Zarantonello , E.H., Solving Functional Equations by Contractive Averaging U.S. Army Math, Res. Centre , Report (1960).

5. Nirenberg, L., Topics in Nonlinear Functional Analysis Lecture Notes, Courant Institute N.York (1974).

6. Chang, K.C. and Shujie, L., A remark on expanding maps, Proc. Am. Math. Soc.,85, No.4 (1982), 583-586.

HTI Calendar of Activities for Academic Year 1996-1997

Prepared by:
M. Poullaides, BSc (Hons), ACGI, MSc, DIC, Senior Lecturer, HTI.
D. Charalambidou-Solomi, BA (Hons), MA, MA (Ed), Lecturer,HTI.
Chr. Antoniou, HTI Dipl., MPhil, Senior Instructor, HTI.

SEPTEMBER

● Two hundred and fifty six (256) new students were enrolled on the regular programmes of HTI. The number of males enrolled was one hundred and ninety nine (199) and the corresponding number of females was fifty seven (57).

The enrollment in the different fields of studies was as follows:

64 for Electrical Engineering (56 males and 8 females)

64 for Civil Engineering (35 males and 29 females)

64 for Mechanical Engineering (57 males and 7 females)

32 for Marine Engineering (all males) and

32 for Computer Studies (19 males and 13 females)

● Dr D Serghides, Senior Lecturer, presented the "Prototype Solar House for Cyprus", an HTI study in the International Conference "Eurosun 96" which was held in Freiburg, Germany, between 14-19 September. She also chaired a session on buildings in the conference, and as president of ISES - Cyprus attended all the meetings of the Board of the International Solar Energy Society.

● Mr D Roushas, Lecturer, attended a Workshop for small and medium size enterprises, which was held in Prague and Brno, between 16-27 September. Five (Production oriented) lectures were given and also eight technical visits were performed in various industries.

OCTOBER

● Two scientists from the National observatory of Athens, Dr Ch Kampezides and Mr M Petrakis, visited the HTI between 29 September - 3 October, within the framework of a collaborative project included in the Scientific and Technical Cooperation of Cyprus and Greece. The project is entitled "Comparison of the performance of solar water heaters using flat plate solar collectors at difference orientation and tilt angle configuration". The Cypriot partners are the HTI (Coordinator), the applied Energy Centre of the Ministry of Commerce and Industry and Tourism, and FLOGA Company managers of solar water heaters. The project was coordinated by Dr Ch Kampezides (Greece) and Dr I. Michaelides, Senior Lecturer, Dept of Mechanical Engineering, HTI (Cyprus).

● Mr C Pavlou, Senior Lecturer, participated in a two day seminar on the European Union programme "Socrates" organised by the Ministry of Education and Culture and the European Union at the International Conference Centre, Nicosia, between 18-19 October.

● Dr A Stasis, Lecturer, participated in a specialised course in Milano, Italy between 21-25 October. The course was fully undertaken by the Company FANUC Robotics Italy, from which HTI purchased a Robot Arm.

The following members of staff of the Civil Engineering Department participated in the 12th Panellenic Conference on Concrete, organised by ETEK (Cyprus) and TEE (Greece) which took place in Limassol between 29 to 31 October.

1. Dr H Stavrides

2. Dr C Papaleontiou

3. Dr C Chrysostomou

4. Mr N. Hadjigeorgiou

The last two presented papers during the conference.

NOVEMBER

● Dr I. Michaelides, Senior Lecturer and Dr S Kalogirou, Laboratory Assistant, participated to the 5th National Conference on Renewable Energy Sources, held in Athens, between 6-8 November. Dr Michaelides presented a paper entitled "Simulation of the performance of thermosymphon solar water

heating systems" and also chaired a technical session on Energy HTI Calendar of Activities. Dr Kalogirou presented a paper entitled "Desalination of sea water with solar energy".

● Mr M Poullaides, Senior Lecturer, visited the University of Glamorgan, U.K. from 23 to 30 November within the program of staff exchanges between HTI and Universities and Polytechnics abroad.

DECEMBER

● Mrs D Charalambidou-Solomi, Lecturer, attended a workshop on "Literary Translation" organised by the Cyprus University in Nicosia on 2 December 1996. The workshop was presented by Professor Susan Bassnett, University of Warwick and Professor Roger Bell, University of Lancaster.

● Mr C Pavlou, Senior Lecturer, attended a meeting at which the Training of Officers of the Ministry of Labour and Social Insurance on European issues was discussed. The Meeting was held at the Cyprus Academy of Public Administration on 9 December 1996.

JANUARY

● Dr A Tamanas, Lecturer, participated in the "First Mediterranean Congress on Mathematics" organised by the Cyprus Paedagogical Institute and the Cyprus Mathematical Society between 2-5 January 1997 in Nicosia.

● Mr S Stergides delivered a series of lectures at HTI on the "Principles of measurement, description and specification of construction works" and on "Site Management". The duration of the course was 60 hours and was held between 8 January - 17 June.

Mr. S Stergides, also, delivered a series of lectures on "Pro-contract Project cost control" and on "Post contract administration and project cost control". The duration of the course was again 60 hours and was held between 10 January - 12 June.

Both of the courses were organised by the Cyprus Group of Civil and Mechanical Professional Engineers in association with the Higher Technical Institute.

● Mr D Lazarides, Director of Higher Technical Institute, Chairman of IAESTE Cyprus, and Mr Ch Chrysafiades, Senior Lecturer, National Secretary of IAESTE Cyprus, have participated in the Annual General Conference in Barcelona,Spain, between 17-23 January 1997.

The Cyprus delegation has justified and secured 39 training places in different countries for HTI students, during the summer period of 1997.

In exchange, 32 training places in 20 major private and public companies in Cyprus, were offered to trainees from the above countries.

● The kick-off meeting for the European Research Project on "Sea water desalination using Renewable Energy Sources" was held at the Higher Technical Institute on the 30th and 31st January. The meeting was attended by the project partners from Greece, Cyprus, Italy, Portugal and Jordan.

The above project faills within the framework of the INCO Programme of the European Union. Cyprus is represented in the project by Messrs S Kaloyirou, I Michaelides and P Elefheriou of the Mechanical Engineering Department of the HTI.

The scope of the project is to design, construct and test two pilot plants, one in Greece and one in Jordan. The budget for the project is 996,000 E.C.U. of which 149,000 E.C.U. is the share of Cyprus participation.

FEBRUARY

● Dr Ch Chrysostomou, Lecturer of Civil Engineering Department, visited Thessaloniki from the 24 to the 28 of February as a participant of the Common Research and Technical Programs between Greece and Cyprus. The purpose of the visit was the exchange of views and the planning of the future of the project. The visit included meetings with professors of the Aristotle University of Thessaloniki and researchers of the Institu te of Technical Seismology and Aseismic Structures.

● Mr P Masouras, Lecturer, participated in the conference on "Effective Skills for Technical Managers" held at HTI between 25-28 February 1997 and organised by the Cyprus Computer Society.

MARCH

● The Department of Mechanical Engineering in collaboration with the CEA organised a short course on "Manufacturing Resource Planning (MRPII) Systems" between 20 February-27 March.

● Dr I Michaelides, Senior Lecturer, visited the National Observatory of Athens (N.O.A.) from 3 to 7 March within the framework of Scientific and Technological Co-operation between Greece and Cyprus. The purpose of his visit was to review the

progress of the joint programme between HTI and N.O.A. on the Improvement of the Efficiency of the Thermosyphon Solar Water Heaters in Greece and Cyprus.

● Mr Andreas Achillides, Senior Lecturer, gave a lecture in the HTI Amphitheatre on The Comet Hale-Bopp" on 27 March.

APRIL

● The Department of Electrical Engineering in collaboration with the IEE Cyprus and the Industrial Training Authority organised a 25hr course between 11-14 April. The course, aimed at Industry personnel, was developed by Merlin Training Ltd, London, and was presented by Mr Neal Hutchinson.

● The Department of Mechanical Engineering in collaboration with the CEA organised a short course on "Statistical Process Control" between 7-11 April.

● Within the framework of the National Technical Cooperation between Cyprus and Greece, the Senior Lecturer, Dr Despina Sergides, participated in seven meetings which were held in Greece between 8-11 April in her capacity as the Cyprus Scientific Co-ordinator for the programme: "Bioclimatic Design for Housing."

● Dr D Serghides, Senior Lecturer, in co-operation with the Cyprus Architects Association and the International Solar Energy Society (ISES-Cyprus) organised a seminar on "Daylighting in Buildings" between 14-18 April. Dr Sergides was also one of the lecturers.

● Mr Ch Theopemptou, Lecturer, participated in a meeting of the European Program EURODESK which was held in Brussels between 17-22 April.

● Mrs D Charalambidou-Solomi, Lecturer, participated in the International Conference on C.P Cavafy organised by the Cyprus University in Ayia Napa between 4-6 April and presented a paper on "The Room - Motif in Cavafy's Love Poetry."

MAY

● The Department of Electrical Engineering in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised a 25 hr course on "Programming in Java" between 13-16 May. The course was developed by Merlin Training Ltd, London, and was presented by their authorised instructor.

● HTI celebrated Sports Day on 7 May by holding various athletic events.

●The HTI Social Formal Dinner was held on Thursday 29 May at the Holiday Inn Hotel in Nicosia. The third year students dined with HTI members of staff and guests from the private and government sectors.

● HTI held a "Cultural Evening" on 15 May at the Skali, Aglantja. Students and staff had the opportunity to enjoy singing, dancing, one act performances and satire.

JUNE

● The Electrical Engineering Department in collaboration with the IEE Cyprus Centre and the Industrial Training Authority organised a 25 hr course on "Building a Web Sive" between 24-27 June. The course was developed by Merlin Training Ltd, London, and was presented by their authorised instructor.

●The Electrical Engineering Department in collaboration with the IEE Cyprus Centre and the Industrial Training Authority, organised a 25hr course on "Windows NT Server" between 3-6 June. The course was organised and presented by a local Microsoft instructor.

● Dr Ch Kampezides and Mr Anastasios Adamopoulos from the National Observatory of Athens visited HTI between 1-5 June within the framework of co-operation between Cyprus and Greece in the scientific and technical sectors. The purpose of their visit was to evaluate the progress of a joint research project on solar water heaters, and exchange views with their Cypriot project partners, members of the HTI Mechanical Engineering Department.

JULY

● The 1997 Graduation Ceremony was held on 3 July at the International Confence Centre in Nicosia.

It was attended by the Minister of Labour and Social Insurance, Mr Andreas Moushiouttas, and the Director General, Mr Nicos Symeonides, dignitaries and guests.

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Tel.: 02-455288, Fax: 02-454875,Tlx: 4907 DHS NSIA CY
Internet Email: L.Joannides@cytanet.com.cy

LARNACA: Yiannos Charalambous, Partner
Elpa Building, 8 Gr. Afxentiou Avenue, P.O.Box 147, CY-6301 Larnaca-Cyprus
Tel.: 04-654042, Fax: 04-657183

LIMASSOL: Chrysostomos Stephanou, Partner
Nicolaou Pentadromos Centre, Ayias Zonis Street, P.O.Box 3309, CY-3302 Limassol-Cyprus
Tel.: 05-346472, Fax: 05-372670

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από το όνειρο... στην πραγματικότητα

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