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THE GRAMMAR OF BIO-MEDICAL ENGINEERING

BY

O. IJAOLA

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THE GRAMMAR OF BIO-MEDICAL ENGINEERING

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Mr. Vice-Chancellor Sir, Deputy Vice-Chancellors (Administration and Academic), and other Principal Officers, Deans, Fellow Professors, my Lords Spiritual and Temporal; distinguished Guests, Ladies and Gentlemen.

It is a great honour for me and a distinct pleasure to have been asked to give the sixth in the series of Inaugural lectures for the Second Semester of the 1997/98 academic session. As an inaugural lecture is obligatory for a Professor in a University, so I stand here before you this evening to deliver the third inaugural lecture from the chair of Department of Electrical/Electronics Engineering - University of Lagos. I was made to understand that it is also the 108th in the series of inaugural lectures at this University, the first of which was given on the 3rd of October, 1962 by late Professor F.O. Dosekun. However, this happens to be the first inaugural lecture to be delivered by one of the Residents of Unilag Magodo Estate, with the added distinction of being the first to be delivered in this country, on Bio-Medical Engineering.

Even though the first inaugural lecture was given in 1962, by the late Prof. Felix O. Dosekun, who was the first Provost of the College of Medicine, the second in the series of inaugural lectures on "A Surgeon Among the Academics" was not delivered until 17th January, 1968 by the late Prof. H. Oritsejolomi Thomas; he was also a Provost of College of Medicine. As the seventh Vice-Chancellor of this University, Professor Jelili Adebisi Omotola chaired his first inaugural lecture, which was the 85th in the series of lectures on the 6th November, 1996, that was delivered by Prof. J.T. daRocha Afodu on *"The Art and Science of Surgery in An Academic Setting."* By the end of this inaugural re, our able, energetic and indefatigable Vice-cellor should have chaired a total number of ty-four inaugural lectures in less than two emic sessions. It is observed here that the Vice-cellor must be given kudos having tremendously oped the University of Lagos educationally, ically, spiritually and academically during his e as the V.C. of this University.

so, it is indeed with a great sense of humility and rous joy that I address you this evening; joy for g been given the opportunity to discharge a duty established by a University of Lagos tradition as f the first responsibilities of a new occupant of rofessorial chair; and humility because of my eness that in discharging this duty, I will share a with many predecessors who distinguished selves in their respective fields of expertise.

s I give this inaugural lecture, I am guided by the ement of late Prof. Paul Omo-Dare, our nguished Professor of Surgery when he gave the in the series of inaugural lectures to this ersity on the 11th November, 1977 on "The ersity Department of Surgery in Contemporary ian Society." He said and I quote:

> "The principal advantage which an occasion such as this gives the new occupant of any of our academic chairs is the opportunity it provides him to formally articulate his thoughts, define and air his views, and may be declare his hopes on some areas of University responsibilities to the society."

aving, therefore, considered a number of topics h might be comprehensible and of interest to this st audience on this August occasion, I came to onclusion that it will be most appropriate for me

to explore with you some aspects of innovative design; construction and maintenance of electronic medical instrumentations and equipment of relevance to Medical Intensive Care Units in Hospitals, and also present my thoughts on our national future needs. Hence my topic titled: *"The Grammer of Bio-Medical Engineering"*

Many centuries ago, David, the writer of the 139th chapter of the Psalms of the Holy Scriptures said, "I will praise God for I am carefully and wonderfully made." For a long time, man has been very conscious about the mysteries of his body and mind - their structures and functions and the diseases that ravage them. Nearly, as old as mankind itself, the practice of medical procedures in some form has paralleled man's development. In most cases the quality or lack of quality of medical services has profoundly influenced the course of civilization. The most ancient available records indicate the existence of two centres of civilization, having nearly equal development, in two of the world's great river systems. In Mesopotamia and in the Valley of North-Eastern Africa, organized people, enjoying the natural endowment of these areas were known to have flourished six thousand years ago.

Prof. Felix O. Dosekun while delivering his inaugural lecture on the 3rd of October, 1962 during the opening ceremony of the College of Medicine on "The Place of Physiological Sciences in Medicine," after tracing the history and evolution of the physiological sciences and making reference to the then newly developed instruments for the study of human physiology like the electron-microscope and electronic instruments, said and I quote:

> "In these various ways and many more, the physiological scientist has not only handed to the physicians a means of more accurate diagnosis of the disease process,

but he has handed him also a means of attacking the agents of disease. But above all, he has taught the physician always to regard disease as a disturbance of the normal homeostatic mechanisms of the body. When the microbe attacks, when the psyche is disturbed, when body cells start to divide and grow rapidly for inexplicable reasons, the human body puts up a fight for survival and it is this struggle that produces the manifestations of the disease."

In this vein, I state that a Bio-Medical Engineer has not only handed to the physician a means of more accurate diagnosis of signs and symptoms of diseases, but also he has handed him medical instrumentations and equipment (like computers, heart-rate monitors, ultrasonogram, electron-microscope, hearing aids, angiograph, X-rays, etc) with which to carry out his investigations and research.

Mr. Vice-Chancellor, Sir, this lecture is being delivered in three major parts. First, I intend to discuss the interdisciplinary nature of Bio-Medical Engineering; Secondly, I will go into discussions on the humble contributions of my research so as to give out my prescriptions to our Universities and the Country at large and thirdly, I will devote some time to opine on our future needs or choices in this country so as to proffer informed recommendations to all hospitals and research institutes in this country.

The major areas of interdisciplinary study of Bio-Medical Engineering are Biology; Microbiology, Parasitology, Medicine and Surgery, Pharmacy, Pure and Applied Mathematics, Public Health Engineering, Bio-Chemical Engineering, Bio-Physical Engineering. Computer Science and Computer Technology,

Communication Engineering, Automatic Digital Control and Systems Engineering. All these bring us to the present day definition of "Engineering in Medicine."

PURE AND APPLIED MATHEMATICS

Professor Chike Obi in his 8-page and 26th inaugural lecture delivered to this University on the 18th March, 1977 on "Mathematics – The Science of Counting" stated and I quote: "Mathematics is a Science." It is also an Art.

It is the Science of Counting. "It is the mother of all subjects." "It is everywhere". Some of the branches of Mathematics of interest to Bio-Medical Engineering are Arithmetic, Algebra, Geometry, Logic, Calculus, Abstract Algebra, Matrices, Statistics, Mechanics, General Topology, Algebraic Topology, Probability Theory, Numerical Analysis, Mechanics of Particles and Systems Mechanics of Solids Fluid Mechanics Electromagnetic Theory. Thermodynamics. Quantum Mechanics. Relativity. Celestial Mechanics. Operations Research Systems Control Elasticity and Plasticity Astronomy. Several Complex Variables and Analytic Spaces. Special Functions, Ordinary Differential Equations (O.D.E.) Partial Differential Equations (P.D.E.) Finite Differences and Functional Equations. Sequences. Series and Summability. Approximation and Expansions. Laplace Transforms. z-transforms. Fourier Analysis. Operator Theory. Calculus of Variations. Differential Geometry. Theory of Catastrophy. Set Theory; Combinatories, General Mathematical Systems, Number Theory, Commutative Rings and Algebras; Algebraic Geometry; Linear and Multi-Linear Algebra; Associative Rings and Algebras; Non-Associative Rings and Algebras. Category Theory; Group Theory; Topological Groups; Real Functions; Measure and Integration Functions of a Complex

Variable and Potential Theory. Others are in the field of Solar Systems of the Galaxy of Ordinary Differential equations: General Theory; Boundary Value problems. Quantitative Theory; Non-Linear Oscillations. Stability Theory. Asymptotic Theory. Differential Equations in Banach Space; Control Problems and Functional Differential Equations.

Medicine and Surgery

The fact that the term "medicine" is used to denote the whole field covered by the Faculty, School or College of Medicine in a university, and also used in the narrower sense to denote only that field which teaches "Internal Medicine" may be a source of confusion in the minds of some. *Stedman's Medical Dictionary* defines Surgery as "the branch of Medicine that is concerned with or treatment of diseases or injuries by operation or manipulation. Also, it is the treatment of injuries or diseases that involve cutting or removing parts of the body by major or minor surgery as in undergoing abdominal/cosmetic open-heart and plastic surgery. *The Oxford Advanced Learners Dictionary* defines a Physician as a Doctor, especially one specializing in areas of treatment other than surgery.

It is observed from these definitions that a Physician is a physiologist, a physiotherapist, a medical microbiologist, Radiologist, and a Radiotherapist

Radiation Therapy (Radiotherapy)

This is the use of high-energy rays to damage cancer cells, which is also ascribed the ability to stop the cells from growing further. Like surgery, radiation therapy is *local therapy*; it affects only the cells in the treated area. It can also come from radioactive materials placed directly into or near the tumour (internal radiation). Radiation therapy is sometimes used instead of surgery for small tumours in the mouth. Patients with large tumours may need both surgery and radiation therapy. Radiation therapy may be given before and after surgery. Before surgery, radiation can shrink the tumour so that it can be removed. Radiation after surgery is used to destroy cancer cells that may remain.

Implant radiation therapy puts tiny "seeds" containing radioactive material directly into the tumour or in tissues near it. Generally, implant is left in place for several days, and the patient will stay in the hospital in a private room. The length of time, nurses and other health care monitors as well as visitors can spend with the patient will be limited.

Primary Health Care

Epidemiological studies have to be carried out nationwide to ascertain the actual prevalence and geographical distribution of the most common parasites. It is important to device preventive training and education techniques, acceptable and understandable to the average rural community. The time is overdue to drum into the ears of the community the fact that many diseases depend mainly on human behaviour and their avoidance can only be achieved by a simple change of behaviours or habits. It is imperative that Nigerians try to change their life styles, or behaviours with respect to health. Of course, the behaviour changes will depend on, or will be induced by the awareness and understanding of the causes of diseases. So, the people must be taught about diseases and how to avoid them. There is a need to base health policies and principles on a switch from the much importance given to urban centres to the rural settlements and from the mature population (adults) to the children, the target population and also from curative to preventive medicine – primary health care.

The *Alma-Ata* (Soviet Union) Conference on Primary Health Care organized by the WHO and UNICEF in 1978 produced a Primary Health Care Declaration stating that and I quote:

> "Primary Health Care is a practical approach to making essential health care universally accessible to individuals and families in the Community as an acceptable and affordable way and with their full participation".

Coupled with the mentioned declaration, the World Health Assembly decided that the main social target of governments and WHO in the coming decades should be the attainment by all citizens of the world by the year 2000 of a level of health that will permit them to lead a productive life. If we could change our life styles and emphasize preventive rather than curative medicine we may be one of the countries that will achieve the target of *HEALTH FOR ALL BY THE YEAR 2010.*

The morbidity and mortality caused by food-borne parasitic diseases will be drastically reduced or be next to nil.

We should declare war against food-borne infections which are a menace to public health in Nigeria and have grave economic consequences. This could be a rewarding challenge. According to WHO, some 35 million people die each year of diseases caused by lack of sanitation and dirty or inadequate water supplies. Most of these deaths are in the third (developing) world. So, efforts should continue to be made to provide all rural communities with uncontaminated potable water, as water contaminated by human faeces is a source of infection for both humans and animals. Dr. A. Mahler, the former Director General of WHO, during the

launching of 'The International Drinking Water and Sanitation Decade", said and I quote:

> "I am utterly convinced that the number of taps per thousand population will be an infinitely more meaningful health indicator than the number of hospital beds per thousand population".

There is a dire need for provision to be made for safe, unpolluted water within a reasonable distance from the home of people in the rural areas. An Expert Committee on Food Safety, which met in Geneva sometimes ago came to the conclusion that illnesses due to contaminated food are perhaps the most widespread health problems in the contemporary world and are important causes of reduced economic productivity. It is clear that the combating of food borne diseases, as an integral part of the Primary Health Care as defined in the Declaration of Alma-Ata, is one of the most effective measures to ensure the noble goal: *HEALTH FOR ALL NIGERIANS BY THE YEAR 2010*

FUNCTIONS OF ENGINEERING

Engineering is an art requiring judgement necessary to adapt knowledge to practical applications, imagination to conceive original solutions to problems, and the ability to predict performance and cost of new devices or processes. The function of the scientist is to know, while that of the engineer is to do. The scientist adds to the store of verified, systematized knowledge of the physical world; the engineer brings this knowledge to bear on practical problems. Engineering is based principally on physics, chemistry, and mathematics and their extensions into materials science, solid and fluid mechanics, thermodynamics, transfer with rate processes, and systems analyses.

The first engineer known by name and achievement is Imhotep, builder of the famous stepped pyramid at Saaqarah, near Memphis. Imhotep's successors – Egyptian, Persian, Greek and Roman – carried Civil engineering to the remarkable heights on the basis of empirical methods aided by arithmetic, geometry and a smattering of physical science. The Phares (lighthouse) of Alexandria, Solomon's Temple in Jerusalem, the Colosseum in Rome, the Persian and Roman road systems, the Pont-du-Gard aqueduct in France, and many other large structures, some of which endure to this day, testify to their skill and imagination.

Medieval European engineers, like the engineers of the classic world, combined military and civil skills to elaborate on their techniques in the realm of construction. In the far east, in India, China, Japan and other regions, engineering had a separate but very similar development, with more and more sophisticated techniques of construction, hydraulics and metallurgy helping to create advanced civilizations.

ENGINEERING AS A PROFESSION

The organization of the engineering profession in most countries reflects the pattern of branching development that resulted in diverse technical societies. This fragmentation is evidenced by the fact that no national or international organization represents all the members of the profession.

The first engineering society, the British Institution of Civil Engineering reflected the new importance of the civil engineer in the 19th century while the Nigerian Society of Engineers established in 1958 attracted mainly Civil and Structural Engineers. As new fields opened up, and new discoveries created the need for specialists, organizations were formed to facilitate the sharing of ideas.

In the developed countries, there are hundreds of technical societies devoted to serving such special interests. Nearly every one publishes a journal containing accounts of the work of its members and conducts meetings to keep members informed of new developments. In some countries, society membership includes the licence to practise in that branch. In others, registration by a government body ensures that those "professing" a knowledge of science and skill in the art of engineering are competent to practise. The requirements usually include being of good moral character, having practised in a responsible capacity for a stipulated period, and passing an examination of qualifications to plan, design, or supervise the construction of engineering projects.

Natural forces apparently work blindly, forcibly and destructively in so long as they are not understood and controlled. But once understood, and their actions, directions and effects are known; it depends only on our ingenuity to direct them as appropriate, to achieve our own ends. One of the best known forces in nature is that exerted by water. When water flows continuously in large quantities, as in a river, it removes all the soil, and destroys all vegetation along its path depositing these indiscriminately in the sea or lake to which it flows. It also creates irregular channels both in depth and width depending on the resistance of the rocks along its path to weathering. An example is the River Niger which automatically erodes, on its course, the desert sand of its upper reaches, the fertile soil of the Savannah grassland and the tropical rainforest. Its flow was so fast over the rapids at Bussa that Mungo Park the explorer died when his boat capsized there. Now, with the construction of Kainji dam on the Niger, the flow of water has been regulated and the required head of water created to drive turbines to generate electricity

Biological Sciences with what happens in practice to achieve his goal.

WHO IS AN ENGINEER?

An engineering project, such as the Kainji or Shiroro hydroelectric or Egbin Thermal project, consists of many engineering activities that it will be impossible for a single individual to acquire in sufficient depth, the knowledge to perform all of them. Its location was determined from maps prepared by the Surveyors, the Engineering Geologists and Foundation Engineers who examined the soil and rocks from this location to solve any foundation problems that arose. The dam wall was constructed by Civil Engineers in accordance with the design made by Structural Engineers which ensured stability against the forces exerted by the impounded water. The size and positions of the turbines for effective utilization of the water at the given heights of water in the dam were determined by the Mechanical Engineer. The Electrical Engineers specified the characteristics of the electrical machines, and brought the power generated by means of high tension transmission lines to distribution stations where feeders; circuit breakers and transformers are used to protect equipment and bring the voltages down to suitable levels required by the consumers. Thus, different branches of engineering had contributed to this important project. The successful execution of such an enormous engineering project involves the engineers, the technologists, the technicians, craftsmen and draughtsmen working as a team. It is relevant at this stage to stress the essential distinguishing features of the engineer from the technologists, technicians, craftsmen and draughtsmen, since it has been stated earlier that there is a great deal of confusion in the minds of the general public as to who an engineer is.

A draughtsman is a person skilled in a particular craft; drawing of civil, structural, mechanical and electrical schematic presentations of the engineers. A craftsman is a person skilled in a particular craft; welding, joinery, bricklaying or auto-mechanic work. His skill is usually acquired over a long period of time. He is a man who is good at doing things with his hands, but with little or no concern about the mathematical or scientific principles of the engineering work with which he is engaged. He is often assisted by unskilled men who with diligence can learn the trade of the craftsman with whom they are working. A technician is a specialist in a specific field where manual skill is needed. He has general training in science and mathematics and studies relevant courses in engineering. He can perform as a draughtsman, laboratory technician, instrumentation technician, concreting and structural specialist or maintenance technician. A technologist is a technician with higher education background up to full or final City and Guilds qualification. The technologists or technician is expected to apply, in a responsible manner, well established techniques in solving certain engineering problems under the supervision of the engineer.

On the other hand, the professional engineer is one qualified by training and experience to perform engineering functions such as the analysis, design, construction of engineering works, production or manufacture of engineering components, research and development of new techniques and materials. To perform these functions he must have a good knowledge of the laws and principles of Physical and Biological Sciences and be able to apply these in solving practical problems. A useful parallel can be drawn between the team working on an engineering project and the army. The professional engineer can be equated to the officer corps, the technician to be non-commissioned officers and the craftsmen, the rank and file. The regimentation existing in an army does not of course, exist in the engineering team, but the "Engineering war" can only be won when each cadre in the engineering team recognizes its role and is contented to play such a role for the success of the team.

DEVELOPMENT OF ELECTRICAL ENGINEERING DEPARTMENT AND OUR HUMBLE CONTRIBUTIONS

The Department of Electrical Engineering was founded in 1964 to offer Undergraduate Courses leading to the B.Sc. (Hons.) Electrical Engineering degree. She took-off through the help of UNESCO experts with some Nigerians both from the Industries and Academia. The Nigerians are Dr. E.A. Akinleye, Late Dr. Benjamin I. Aror, Dr. Omotayo. A. Seriki (now Prof. Omotayo A. Seriki of Siemens) (from ECN now NEPA). By the time I joined the department, I met Dr. Olusegun Ajayi (who has contributed enormously to the building of the Department of Electrical Engineering). Mr. Ganiyu A. Mustapha (now Dr. G.A. Mustapha of the Nigerian Defence Academy - Kaduna) , Mr. R.I. Salawu (now Prof. R.I. Salawu) and Mr. Tajudeen A. Kasim (late Dr. Tajudeen A. Kasim). Between 1971 and 1973, the department got the services of Dr. Alberto J. Alos from the University of Ife (now Obafemi Awolowo University). He is Prof. Alberto J. Alos of Lagos Business School; Dr. Patrick Delwide (from Stanford University), Dr. D. Pulleyblank (from Princeton University, USA), Dr. A.C. Jani (from Imperial College) and Mr. E. Bolton from an industry in Britain. By the academic session in 1975/76, the department had secured the services of 3 Egyptians from Cairo University - Prof. F.S. Atiya, Prof. El-Arabaty

and Dr. D.S. Dawoud.

I was employed by the University Council on October 1st, 1970 to the Department of Electrical Engineering. Apart from the numerous papers and publications (including textbooks) which the staff had produced since its inception in 1964/65, the Department has produced about 1,200 B.Sc. (Hons.)Electrical Engineering graduates; 150 M.Sc. (Electrical Engineering): 2 M.Phil. (Electrical Engineering); 5 Ph.D. (Electrical Engineering). Out of about these 1200 graduates with B.Sc. (Hons.), the department has produced well over 60 First Class Honours graduates in Electrical Engineering with the first set of three (3) First Class Honours graduates produced in June 1972: Mr. Oluwole Adegbenro, now Dr. Oluwole Adegbenro, a Senior Lecturer; Mr. C.O.A. Awosope, now a Professor in the department of Electrical Engineering and Prince M.A. Kasali GM (GT&E) in NEPA. In fact, the department of Electrical Engineering has produced the same number of First Class (Hons.) graduates as the total put together, produced by the other Departments of Chemical, Civil, Mechanical and Surveying in the Faculty of Engineering.

It is regrettable that even though the department has produced so many First Class Division graduates in the past eight years; none of these graduates has come to take up an appointment as a Lecturer. When we recognise that the present corps of Professors in the Department would retire in about a decade, it becomes a matter for serious concern.

We in conjunction with Late Dr. B. I. Aror, started from scratch, the Automatic Control Laboratory of the Department of Electrical Engineering through the assistance of UNESCO and the Feedback Company Ltd. of Great Britain. It is particularly gratifying to observe that the Laboratory is still functional to date, in spite of all odds.

THE CONCEPT OF BIO-MEDICAL ENGINEERING

It may be said that the modern Bio-Medical Engineer is at once a Mathematician; a professional Engineer; an applied Physicist and an amateur Cardiologist. When interpreted in fundamental terminology, we find that Bio-Medical Engineering is perhaps as old as man, and it is for this reason that one makes bold to say that the *Grammar of Bio-Medical Engineering* has raged from time immemorial and it will continue to rage until the end of man. It is, in fact, the grammar of everyday life for Bio-Medical Engineering pervades all human endeavours and aspirations. Indeed, all the anxieties about how well we live, economic development, the eradication of apartheid and etc are proxies for the grammar of Bio-Medical Engineering. No wonder, therefore, an adage says "Health is Wealth".

It is natural that the Grammar of Bio-Medical Engineering has to start with the fundamental question - What is Bio-Medical Engineering? In answer to this question, Mr. Vice-Chancellor Sir, I wish to suggest that Bio-Medical Engineering which may be described as essentially electronic instrumentation in medicine is easily the most sought after, the most frequently condemned and the least understood element in the World. The discovery of X-rays by Roentgen in 1895 provided a useful diagnostic tool in medical practices. The wars of Religion (16th and 17th centuries); World Wars I and II; Korean War and Vietnam War increased our knowledge of Bio-Medical instrumentations and equipment. These revolutionary historical landmarks prepared the way for the wide scope of modern practice of Medicare, created the modern intensive care units and techniques where the rule of life saving is urgently made.

WHO IS A BIO-MEDICAL ENGINEER?

He is one qualified by training and experience to perform engineering functions such as the analysis, design, construction of engineering works, production or manufacturing of engineering components, research development of new techniques and materials in the field of medical equipment and instrumentations. We now discuss four out of our many innovative ideas in the field of Bio-Medical Engineering.

1. HYPERTHERMIA AND ELECTROMAGNETICS RADIATION IN CANCER THERAPY

We started our humble contributions in this field of Cancer Therapy in 1984 as a result of discussions with my supervisors - Profs. Bob Newcomb and Nicholas Declaris of the University of Maryland, Department of Electrical Engineering, College Park, Maryland, U.S.A.

We had observed that five major sensitive organs are very vital for an adequate diagnostic analysis of human ailments; they are, the heart, the lungs, the blood system, the kidneys and the brain. These are sufficient to enable a physician obtain 90% picture of what is going on in an abnormal or minimally functioning physiological structure as declared by Guy (1960): "Human Anatomy"; *Eccles J.C.* (1951): the "Physiology of Nerve Cells" and "Cumminghams Manual of Practical Anatomy Vols. 1, 2, and 3, 11th Edition", edited by G.J. Romanes (1979). These biological tissues are believed to be affected by Electromagnetic radiation. It is consequently of utmost importance to have a sound theoretical knowledge of the effect of electromagnetic radiation on these organs. Our study pertained to the human organs and our results provided a clearer insight into the manner in which these tissues respond to radiation and this we hope would in its turn, lead to a better understanding of the behaviour of these organs.

Cancer is the number two cause of death, only exceeded by heart diseases. Roughly, one out of four persons will contract cancer at some point during their life, and despite the tremendous efforts devoted to identifying a cure, only about one-half of the total patients will survive the various diseases categorized as cancer. A form of cancer therapy that has received a resurgence of interest in recent years is the use of heat to cause elevated tumour temperatures in the range of 42°C to 45°C or higher (hyperthermia). It is impossible to answer meaningfully the question of the efficacy of hyperthermia as a clinical modality until heat delivery systems have achieved a degree of sophistication that gives the clinician, devices which can produce temperature distributions in tumours such as the minimum tumour temperature of 42° C or greater. In larger part, the success or failure of hyperthermia as cancer modality depends on the Engineers and their ability to solve the extremely difficult problem of effectively heating tumours while sparing normal tissue.

We studied in the first instance, theoretically, the effect of Electromagnetic waves such as the Microwaves and laser radiation on biological tissues. In relation to the brain, for instance, we investigated the internal heat generation resulting from the bombardment of the brain by radiation, paying particular attention to the role of the brain size as well as the size of the head. The problem was formulated in a general form to take account of the "cooling" effect of the blood flow. As a result, while the main body of our investigations was analytic, the complexity of the problem necessitated a considerable amount of numerical occupation to effectively conclude the investigation [Ijaola, 1984].

Also, we studied one of the critical problems in hyperthermia field which is the design, development and testing of innovative and better hyperthermia systems like special injection needed to generate a temperature of 42° C and above on the affected tissues of the tumor. Hyperthermia systems working at frequencies around 150MHz and which are useful for a penetration depth of 3-4cm in tumor and muscle tissues were successfully investigated [Ijaola, 1985].

2. DIGITAL HEART RATE MONITOR (BIO-MEDICAL INSTRUMENTATION)

The digital heart rate monitor (a Bio-Medical instrumentation) measures the degree of cardiac disorders in a patient. The cardiovascular disorders have constituted a major public health problem in developing countries. Studies have shown that the profile of morbidity and mortality from heart diseases are largely ecological, psychological, physical and socio-economic but varies from place to place. However, cardiac symptoms within these nations are known to attract diagnosis only at the patients critical conditions. In the innovative design and construction of this heart rate monitor [Ijaola , 1996], we presented a fundamental theory of cardiac disorders and a design of a non-invasive instrument for its prognosis and effective management. While most modern Bio-Medical instruments are complex and expensive, we focus on the Monitor's simplicity and fidelity. The characterization carried out in various tests on the prototype monitor produced satisfactory performance profiles, thus indicating that they can be adopted for use in our general and private hospitals, clinics, research laboratories and teaching hospitals. Components of a typical medical instrumentation include a sensor, signal conditioner (Filter), amplifier and a recorder.

The development of modern technology is known to have led to a profound revolution in medical electronics system. The Bio-Medical engineering revolution is being developed and has reversed the ancient medical practice of treating diseases and organic malfunctions after they have occurred. Electronics has the potentials to reveal advance clues to every known disease and malfunction; this has created enormous challenges for Engineers and Scientists. The advent of Bio-Medical Instruments has led to constant emphasis on disease identification and preventive treatment. These instruments have become more complex and so expensive in both acquisition and operation, that most developing nations, which are predominantly rural, peasant and illiterate are seriously trailing behind in medical prognosis.

Makulkin Vladimer Ivanorich and Ovcharenko Segei Ivanorich of the Russian Republic in 1987 described the reliability of the manual method of counting the variation in heart beat locally to suspect a heart disorder when a patient is in an intense condition of breath. In 1972, Howard M. Yanof a Soviet Engineer in his innovative Bio-Medical instrumentation (electronics) contribution used sensitive electrodes attached to the human body and connected it to an amplifier that amplifies the detected signal to a magnitude that can easily be seen for diagnosis. His electronic system is acceptable worldwide, of which the electrocardiogram is a major product for detection of electrical signals from the human body through an electrode.

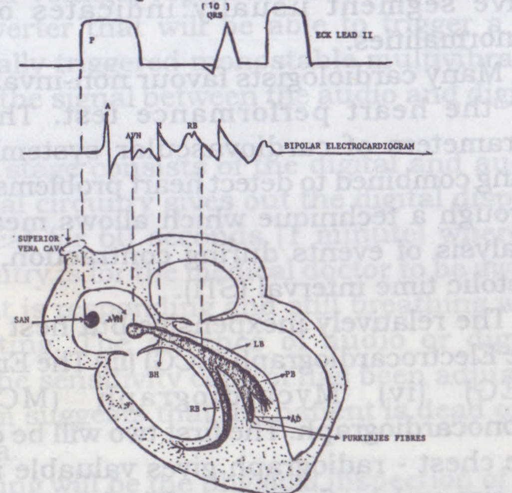
Our digital heart rate Monitor presents a different approach that detects heart beat without electrical contacts with the electrodes. A light beam method is utilized in the design. The Monitor uses light passing through a fleshy part of the finger and as the heart

beats, the pulse at the finger creates a pulsating shadow which is picked up by a light sensor and recorded digitally for a period of 60 seconds to determine the rate.

PHYSIOLOGY AND PERFORMANCE OF THE HEART

The function of the heart is to pump sufficient oxygenated blood containing nutrients, metabolisms, and hormones to meet moment-to-moment metabolic needs and preserve a constant internal milieu. The heart has two essential characteristics. Contractility and rhythmicity. The nervous system and neurohumoral agents modulate relationship between the various return to the heart, the outflow resistance against which it contracts, the frequency of contraction and its inotropic state and there are in addition intrinsic cardiac autoregulatory mechanisms.

Electrical events initiate the cardiac cycle with depolarisation of the sinoatrial node in the right atrium near the orifice of the superior *vena cava* (Fig. 1)



(Fig. 1): Diagram Progression of Conduction in the heart and the relationship between Anatomic Structure and the events observed in a limb electrocardiogram and in an electrocardiogram recorded from a transvenously inserted bipolar electrode positioned close to the conduction bundle.

where SAN denotes Sinoatrial Node; AVN represents Atrioventricular Node; BH stands for the Bundle of His; RB is the Right bundle branch; LB is the Left Bundle branch; PD is the Posterior Division while AD is the Anterior Division.

The first phase of the electric cycle causes the two atria to contract. Consequently, it is known as the atrial depolarization phase of the cardiac cycle. The final phase in the cycle called the repolarisation phase is the relaxation of the heart muscle. Atrial depolarization or contraction of the two atria occurs at point P known as the P-wave. After being delayed by the A-V node (this corresponds to the P-Q interval), the pulse then causes the sharp ventricular contraction. This is seen as the QRS complex. Finally, at the end of the cardiac cycle, replorisation or myocardium relaxation occurs. This is observed as the T-wave. The U-segment prior to the next P-wave helps to indicate cardiac muscle relaxation. A depressed T-wave with a depressed U-wave segment usually indicates one or several abnormalities.

Many cardiologists favour non-invasive techniques for the heart performance test. The well known parameters of cardiovascular system operation are being combined to detect heart problems non-invasively through a technique which allows measurement and analysis of events during contraction, known as the systolic time interval (STI).

The relatively inexpensive but hest Radiograph (ii) The Electrocardiograph (ECG) (iii) The Encypharlograph (EEG) (iv) Mycardiograph (MCG) and (v) Phonocardiograph. The first two will be explained here. The chest - radiograph gives valuable information on the size and configuration of the heart, bone- structures and the entire pulmonary vasculature. It is taken in inspiration in the posterior-anterior (PA) position, with the patient at a distance of 1.8m from the x-rays tube.

The electrocardiogram (ECG) is a surface recording of the cardiac potentials arising from the passage of the normal electrical impulse through the heart. The Phonocardiograph is an instrument for the detection and recording of heart sounds.

DESIGNING OF THE MONITOR

The design processes of the Monitor is divided into three (i) The input stage (ii) The signal processing stage and (iii) The output stage. The input stage has the sensor/pulse detector unit comprising of the pre-amplifier and a medium stage amplifier. The pre-amplifier utilizes a highly sensitive programmable Integrated Circuit (IC) the LM4250CN which accepts a small input voltage (in microvolt) and amplifies without attenuating the signal to a desired level of gain that the designer specifies. The monitor has a gain of 10. The signal processing unit amplifies the incoming pulsating signal voltage, reprocesses it by passing it through an inverter that will be able to trigger a 60 seconds manually triggered monostable multivibrator to synchronize the signal between the audio and digital circuitries.

The output stage consists of the digital and audio parts, the digital circuitry gives out the digital display of the heart beat for 60 seconds (1 minute) whereas the audio-circuitry is for the medical doctor to be aware that the patient is responding and still breathing with the heart beating. The absence of audio or digital readout after the sensitivity control has been adjusted to its maximum suggests that the patient is dead or in a state of coma.

The next thing will be the physical inspection of the condition of the patient. The input stage uses a high sensitive optocoupler to eliminate the cause of noise and radio frequency interferences into the system, as the opto-isolator diode lights, it is indicative that the system responds and the output taken via the collector of the transistor. A typical circuit used in achieving it is displayed in fig. 2. *(Next page)*

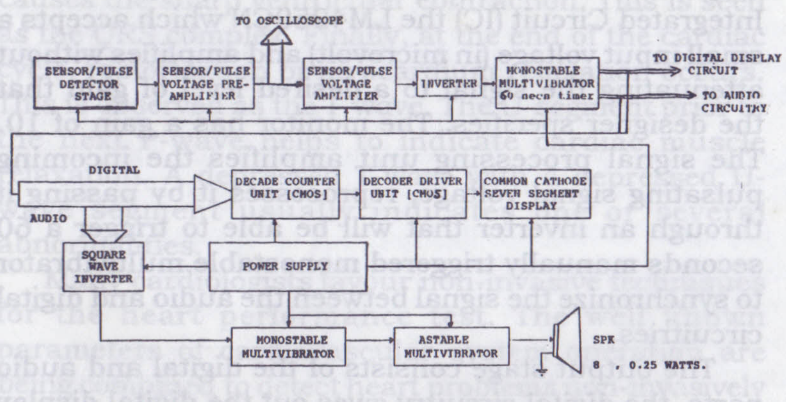


Fig 2. Block Diagram of a Heart Beat Monitor

PERFORMANCE OF THE MONITOR

A laboratory test was carried out using both the light beam method and the two electrodes methods with satisfactory results. The use of electrode is to ensure that in the two electrodes, one is placed in the body part to respond to the positive deflected wave whereas the other is placed opposite the first to respond to the negative wave during heart relaxation. The light beam method uses a light dependent resistor (LDR) encased in a small hollow with an intense light intensity at right angle opposite the LDR for maximum illumination. Any

casting of shadow or obstacle as the blood is pumped changes the resistance of the LDR and is thus recorded as a pulse for the length of time the obstacle persists. It is on that basis that the heart rate can be calculated with time.

Patient safety is taken care of in the designed system, since 1 milliampere of current passing through an unhealthy patient will lead to a fatal state due to ionic imbalances in the patients blood constituents; improvements on how to reduce body contact with the electrode was achieved and assures the patient of a safe, reliable and easy method of picking up electrical impulses from the heart through the body.

RESULTS AND CONCLUSION

Two sets of results were obtained from the designed equipment. One set of results presents a tabulated characterization of heart diseases by testing various patients at the Outpatient Department (O.P.) Units of various locations in an hospital. (Table 1)

Type of CARDIAC DISORDER	Heart Rate	
	Adults (Male & Female)	Infants Children
1. Second degree heart block (Wenchbach)	32, 30	
2. Third degree heart block (Complete failure)	26, 28, 28	
3. Ventricular Fibrillation	62, 66	
4. Atrial Flutter	76, 74, 74	
5. Atrial Fibrillation	77, 80, 74	
6. Super Ventricular Tachycardiar (SVT)	96, 94, 98	
7. Ventricular Tachycardiar (VT)	108, 112, 110	
8. Sinus Rhythm	70, 72 70, 68 (5 patients with normal ECG Signal)	100. 120, 100 (for 3 Children)

Table 1: Experimental Results Obtained and the Suspected Heart Disorders

The other sets of results were obtained still in the same hospital with the designed equipment incorporated to the hospital x-y plotter. A medical consultant helped in interpreting the results and when compared with those available in reputable technical journals, they proved reliable and acceptable.

Our results suggest that a heart rate (diastolic) either above or below normal of 60 to 80 for an adult (depending on his/her age) is indicative of one or more organic malfunctioning of the heart. Its causes might not be necessarily connected with cardiac disorder but can be either due to liver malfunction, electrolyte abnormalities in the blood due to the effect of drugs or problems created by hereditary factors. It is recommended that people who have problems of breathing difficulty and chest associated problems should be on monthly routine medical check up with the medical doctor in the hospital and as often as they feel uncomfortable.

3. INNOVATIVE SIMULATION OF MECHANICAL HEARTS

Among our humble contributions to the field of cardiology is a result obtained when a mechanical heart was designed and simulated and presented solely at the 1978 International Conference on "Computers in Cardiology" at Stanford University, Stanford California, U.S.A. [Ijaola, 1978].

Any computer simulation of the cardiovascular system must make many assumptions so that a computer of reasonable capacity may be used. At the same time, the overall accuracy of the simulation must not suffer greatly. With this in mind, we divided the cardiovascular system into eight separate sections. These sections are (i) the left ventricle (ii) the right ventricle (iii) the aorta (iv) systemic arteries (v) the

systemic veins (intra-thoracic (vi) system veins (extra-thoracic) (vii) pulmonary veins and (viii) pulmonary arteries. The design of computer simulation in the cardiovascular system will proceed by successive approximations since the statement of the problem is never complete for an engineer to work independently of the physician. Both are required to cooperate and learn from other's trade.

We have shown that it is possible to determine twenty-four different flow pressure or volume wave forms with our simulation. The main purpose then will be to predict the flow and pressure wave forms of the cardiovascular system, particularly near the heart.

For nearly a century or so, whenever a new piece of medical equipment is developed, an extensive series of tests is performed before serious thought is given to the possibility of using the device to sustain a human life. Since the heart is the most important organ in the body, any mechanical heart that is proposed for human use can expect to undergo an extremely demanding series of tests. Presently, pulsatile mechanical heart assisted devices, mechanical hearts for use during open heart surgery and implantable mechanical hearts are being developed. Generally, the testing procedure for these units consists of an engineering evaluation to determine flow and pressure characteristics independent of any physiological factors, followed by experimentation with animals usually dogs or rabbits.

For several reasons it is deemed desirable to supplement the present test and evaluation procedure with tests using simulated model of the circulatory system. Such a model would greatly aid in the development of mechanical hearts and heart assisted devices. Although the final experiments with animals could not be eliminated altogether; animal tests would only be needed to verify the results obtained from models and as a check on any undesirable physiological characteristics of the devices that might not have become apparent through other tests. Animals would no longer have to be used as an integral part of the development of a mechanical heart because there would be an alternative method of determining many of the physiological consequences of any design changes. More is involved than just the elimination of a certain percentage of animal experiments. The use of a model to test mechanical heart devices would offer the repeatability found in physical experiments as opposed to the variations common to most physiological experiments. The model could be built to handle the flow and pressure levels found in the human body, thereby eliminating the differences in size between dog and man. Finally, it is almost certain that a mechanical heart would only be used for humans that are already sick in some way.

Pathological conditions could be introduced into the simulation while the occurrence of any desired pathological state in any given test animal is, at best, somewhat uncertain. Figure 3 shows the block

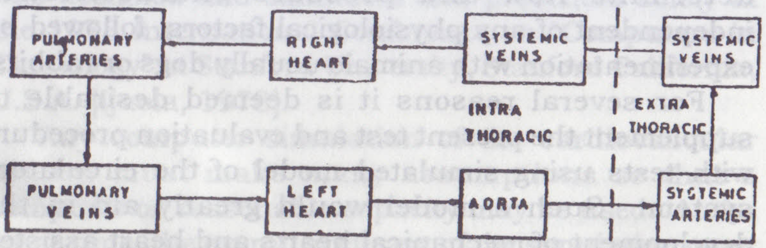


Fig. 3: Block Diagram for the Cardiovascular Simulation

diagram for the cardiovascular simulation. The atria have been included in the systemic and pulmonary

veins because they contribute little to the overall performance of the heart other than serving as reservoirs. The basic division between the intra and extra thoracic segments has been made to allow for the slightly negative pressure that occurs in the Chest Cavity.

Except for the two ventricles, each segment in the simulation can be described by a set of three equations of similar form. For each portion of the cardiovascular system the volume V depends upon the difference between the inflow F_1 and the outflow F_o and upon the initial V_o. Mathematically, it is given by the following expression:

$$V = V_o + (F_1 - F_o)\,dt \qquad (1)$$

The pressure in a blood vessel may be approximately given by the piecewise linear function described as

$$P_1 = \frac{1}{C} V - V_u, \quad for\ V > V_u \qquad (2a)$$

$$P_1 = 0 \quad , \quad for\ V < V_u \qquad (2b)$$

where C = DV/DP (compliance); V = volume of the blood vessel and V_u = the unstressed volume, P_1 = the transmural pressure throughout the blood vessel.

Assuming that the flow from one segment to the next is proportional to the difference in pressure between the two segments, the outflow F_o can be derived from the relation:

$$P_1 - P_2 = RF_o + L\frac{dF_o}{dt} \qquad (3)$$

where $P_1 - P_2$ = difference in pressure between the segments.
R = resistance to flow
L = inductance or inertance.

The three equations describing the aorta are

$$(V - V_u)_{AO} = (V - V_u)_{AO} + \int (F_{LVAO} - F_{AOSA})\, dt \qquad (4a)$$

$$(P_{AO} + P_{TH} - P_{SA}) = R_{SA} F_{AOSA} + L_{SA} \frac{dF_{AOSA}}{dt} \qquad (4c)$$

$$P_{AO} = \frac{1}{C_{AO}} (V - V_u)_{AO} \qquad (4b)$$

The intrathoracic pressure P_{TH} has been added to the basic set of equations because the aorta is mainly within the thorax while the systemic arteries into which the blood is flowing are mainly in the extra - thoracic region. For all other blood vessels the inductance was neglected.

We now describe the ventricles mathematically. As the heart beats, the pressure inside a ventricle increases while the internal volume decreases. The changes could be simulated as a time varying compliance for a ventricle. This method has been used by other investigators because of its simplicity and associated reasonably good results. Beneken (1965) had suggested that the ventricular elastance (which is the reciprocal of compliance) be varied in the manner of Fig. 4. The equations governing a ventricle are:

$$V = V_o + \int (F_i - F_o)\, dt \qquad (5a)$$

$$P_1 = VE(t) \qquad (5b)$$

$$(P_1 - P_2) = RF_o \qquad (5c)$$

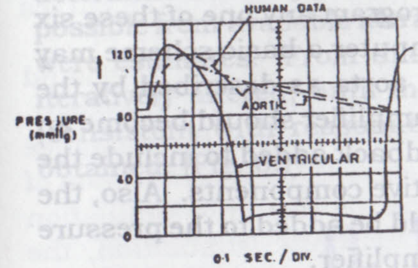


Fig. 4a: Ventricular and Aortic Pressure

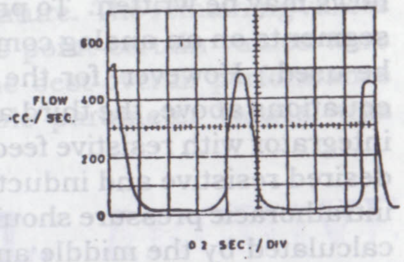


Fig. 4b: Low Leaving the Aorta

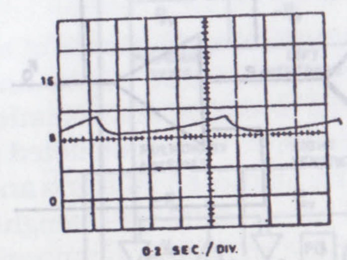


Fig. 4c: Filling Pressure of the left ventricle.

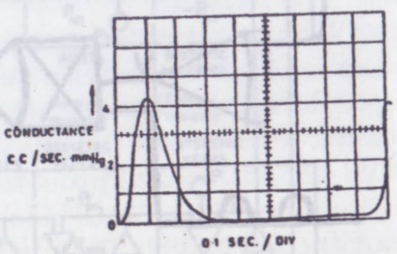


Fig. 4d: Conductance Curve

where E(t) is the elastance wave form. It is the periodic variations in the elastance curve that produce the simulated cardiac output. The resistance R in the equation represents the resistance of the aortic or pulmonary valve. Although, the pressure drop across a valve is proportional to the square of the flow through it, the heart valves have been approximated by a linear resistor. This is an acceptable simplification because the pressure drop across a heart valve is small anyway.

For the six venous and arterial segments in the block diagram eighteen equations having six unknown pressures, six unknown volumes, and six unknown flows may be written. To program any one of these six segments on an analog computer a basic scheme may be used. However, for the aorta as described by the equations above, the third amplifier should become an integrator with resistive feedback added to include the desired resistive and inductive components. Also, the intrathoracic pressure should be added to the pressure calculated by the middle amplifier.

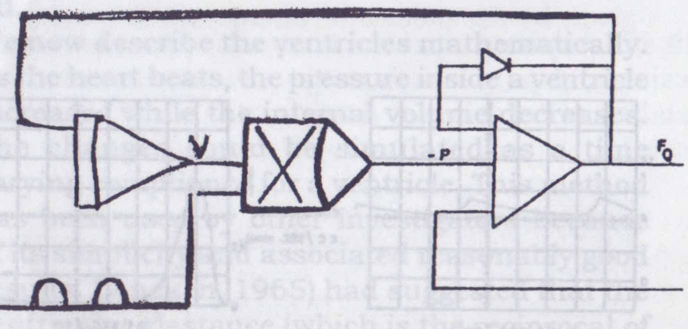


Fig. 5: Computer Diagram for a Ventricle

Figure 5 shows the computer simulation of a ventricle. The multiplier is used to introduce the elastance curve. The elastance curve comes from a function generator. This computer diagram represents the simulation of six sets of three equations similar to equations 4a, 4b and 4c; and the two sets of three equations similar to equations 5a, 5b and 5c. There are eight unknown volumes, flows and pressures.

In order to make the computer simulation workable, we need to determine the values of six compliances,

eight resistances, one inerctance, the thoracic pressure, the elastance curves for both ventricles, and end diastolic volumes for each of the eight segments to serve as initial conditions on the eight integrators. We determine as many of the values of the parameters as possible from available literature. The remaining values were estimates. From this point certain values were iteratively altered, until the best overall performance (consistent with reasonable parameter values) was obtained. (Fig. 6:)

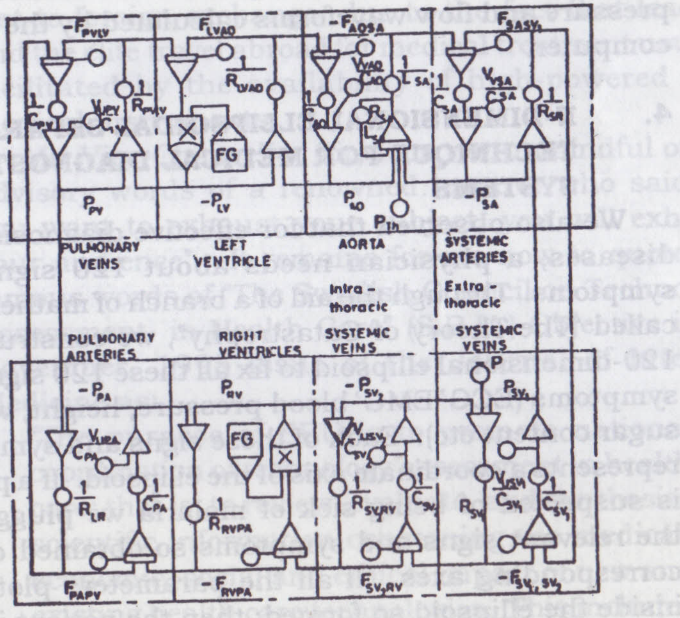


Fig. 6: Computer Diagram of Simulation

It is possible to determine twenty-four different flow, pressure, or volume wave forms with this simulation. As the main purpose of this computer simulation is to predict flow and pressure waveforms near the heart, only those curves will be considered. While the relative values of the aortic pressure curve predicted here are near normal, the fine detail of the discrotic notch is clearly missing. The high degree of accuracy and the absence of fine detail seen here is typical of the curves occurring throughout the simulation.

It is observed that the computer simulation should be synchronized to the beating of the mechanical heart. This requires that the systolic portion of the elastance curve be generated beginning with each contraction of the mechanical heart. When the computer simulation is included in the overall hydraulic simulation, the anticipated variations in the pulse rate will modify the pressure and flow waveforms calculated by the analog computer.

4. N-DIMENSIONAL ELLIPSOIDAL SEPARATION TECHNIQUE FOR MEDICAL DIAGNOSTIC SYSTEMS.

We also observed that for effective diagnosis of all diseases, a physician needs about 120 signs and symptoms. Through the aid of a branch of mathematics called "The Theory of Catastrophy", we constructed a 120-dimensional ellipsoid to fix all these 120 signs and symptoms (ECG' EMG' blood pressure, height, weight, sugar content etc). Each of these signs and symptoms represents a coordinate axis of the ellipsoid. If a patient is suspected of being sick of malaria we plugged all the relevant signs and symptoms so obtained on the corresponding axes. If all the parameters plotted is inside the ellipsoid so formed; then the patient is sick of malaria. If not he is not having malaria fever. [Ijaola, 1977].

RECOMMENDATIONS

That we have a disturbing dearth of experts in Nigeria to engage in high powered Bio-Medical Engineering research and training of personnel in this field is as sure and true as the day follows the night. It is imperative that result-oriented design and construction of application-specific medical instrumentations with control equipment be initiated without further delay in all the private and public medical institutions. This will allow the Medical Instrumentations and equipment to be properly maintained, as billions of Naira are being wasted away for lack of proper care and maintenance. Also, a lot is lost to foreign exchange, due to the fact that leaders and the elite travel abroad for medical treatment usually facilitated by the availability of high-powered bio-medical instruments.

Mr. Vice-Chancellor Sir, I am not unmindful of the advisory words of a renowned lecturer who said: "If you want to exhaust your subject, you will exhaust your audience". It remains for me now to quote the famous words of "The Swedish Council on Technology Assessment in Health Care" (S.B.U.) Objective in its November, 1995 issue of the Journal of Internal Medicine as:

> "The purpose of SBU is to promote national coordination of technology assessment in health care; that is, to review, evaluate, and synthesize scientific information concerning the medical, economic, social and ethical impact of new and existing health care technologies. This includes the promotion of new technologies based on safety and cost-effectiveness, as well as preventing the inappropriate diffusion of new technologies that have not been evaluated for safety and effectiveness."

It is no wonder then, that we are here appealing to the Federal Government of Nigeria to establish as a matter of urgency "The National Council of Technology Assessment in Health Care" (NCTAHC) to be charged with the following responsibilities:

(i) to identify new or established medical technologies needing assessment;
(ii) to establish on scientific grounds the clinical, economic, humanitarian, and social value of using such medical technologies;
(iii) to publish scientific reports, with appropriate degree of detail, that will be accessible to health professionals as well as national and local policy makers;
(iv) to promote the rapid introduction of new medical technologies that replace those that are less safe and less cost-effective.
(v) to educate and inform the public at large about the findings and other activities of technology assessment.
(vi) to serve as a national and international focus for medical technology assessment activities.

The Government should as a matter of urgency establish a Federal College of Bio-Medical Engineering Technology to train specialized technologists to maintain all the medical equipment and instrumentations in all the teaching hospitals as well as public and private hospitals.

Graduates of this established Federal College of Bio-Medical Engineering Technology should undertake an intensive six-months Industrial Training with the Manufacturers of Medical equipment and instrumentations such as Siemens and Philips. This will allow them to study in depth and be conversant with the equipment and instrumentations already installed and to be installed in the National teaching

and general hospitals. This will also reduce to the barest minimum the foreign exchange usually spent to invite expatriate technicians/technologists for repairs of these medical instrumentations and equipment.

That Government should liaise with the UNESCO so as to establish a Regional training maintenance centre for Bio-Medical Engineers in Nigeria for the Sub-Saharan Regions.

That a Bio-Medical Technological Commission be established by the Federal Government; charged with the responsibilities of Workshops; Seminars and Conferences on the Maintenance and installation of all medical instrumentations and equipment in national teaching and general hospitals, Research Institutes and all agencies engaged in Health Care Delivery.

That at least 2% of the total costs of all the medical equipment and instrumentations should be voted and paid to this National Bio-Medical Technological Commission for the Maintenance of Medical Equipment and Instrumentations by this Bio-Medical Maintenance Centre. This will enhance the status of medical instrumentations and equipment maintenance culture of this country in Hospitals and all private and public agencies engaged in Health Care delivery.

That the Regional Training and Maintenance Centre so established should have the following divisions to handle the equipment and instrumentations peculiar to the division: (1) Surgery (2) Medicine (3) Obstetrics and Gynaecology (4) Paediatrics (5) Physiotherapy (6) Eye Clinic (7) Ear, Noses and Throat (ENT) (8) Community Health Centre (9) Radio - Diagnosis Centre (X-rays).

ILL-MANAGED HOSPITALS

Acquired Immune Deficiency Syndrome and other infectious diseases currently ravaging the nation's populace are spreading through ill-managed hospitals in the country.

It is unfortunate that after almost 38 years of our independence, there is no legally established professional body to regularly inspect and approve hospitals and clinics in Nigeria whether built by the government or the private sector. There are many established, unregistered health facilities manned by quacks who call themselves doctors, while some paramedical staff examine patients and prescribed drugs for them.

As health matters are in the concurrent list, the states and the Federal Government should set up a professional body to inspect all hospitals and clinics in Nigeria to ensure that they meet the required standards and have the required facilities before they are approved. Specifications on what must exist in every hospital, clinic and public health institution must be clear and uniform in all the states of the federation and all those who do not meet the requirements should be closed down immediately.

We are recommending that the Government should establish without delay "The Professional Hospital Inspection Commission", a body which would be independent of state governments to inspect health institutions all over the federation every four years so as to ensure the following:

i. That each medical institution fulfils the required conditions and have the facilities expected of hospitals, clinics or public health institutions
ii. to establish approved system of record keeping for patient, both in-patients and out-patients

iii. that where the institution collect blood it should have a blood bank and facilities for HIV screening
iv. to inspect thoroughly all the various medical instruments installed in those institutions by technical team of experts so as to comply with the standard and specifications of those gadgets and finally
v. to inspect and approve new hospitals or clinics before they are opened to the public.

As the chairman of the development committee of an Interdisciplinary programme for the undergraduate course leading to the B.Sc.(Hons.) in Bio-Medical Engineering, we submitted a comprehensive recipe_for a five year course in Bio-Medical Engineering to be a joint programme between the College of Medicine and Faculty of Engineering in 1982/83 session. The best that the University was able to do then was to establish a Department of Bio-medical Engineering in the College of Medicine to train technologists, to handle repairs and maintenance of medical instrumentations and equipment. I believe that this was due to the fact that pressures came from WHO to establish a regional training centre in sub-saharan countries.

We recommend that the University of Lagos should establish without delay a department of Bio-medical Engineering within the Faculty of Engineering based on our recommended interdisciplinary course programme proposed to the senate in 1982/83 session leading to the award of B.Sc. (Hons.) Bio-Medical Engineering jointly by the College of Medicine and Faculty of Engineering of the University of Lagos.

A. A. Abass of the University of Port Harcourt; in the National Concord of February 24, 1987 stated and I quote:

"Our health services are undeveloped, our structure of health care delivery is colonial and ambivalent, our manpower irrelevant to solve out health problems and there is no viable health industry to save our people from diseases and epidemics. A nation without a political commitment to the health care (intensive) development would continue to have just mere consulting clinics all over the country. The level of outbreak of epidemics of several diseases in Nigeria is intolerable and it is an index of backwardness in health care delivery".

Since independence we have not got a national health plan and this the then Honourable Minister of Health, Professor Olikoye Ransome-Kuti has attested to. The health sector must now be given better attention. There can be no true and meaningful economic recovery without a healthy people. Time is now for a definite action on health care in Nigeria. It is a decision that must be made by the Federal Government in Nigeria and it is only in this way that Nigerians can have hope that we are not just having a heavy health bureaucracy but a healthy and effective health service.

Mr. Vice-Chancellor, Sir, we must do all that is necessary now to control the myriad of parasitic infections in Nigeria. But to carry this out successfully, we need personnel. To have trained personnel, we must have training posts, that is, departments that are exclusively committed to Bio-Medical Engineering aforementioned and training of people in the area and not just appendages or adjuncts to any other department. To have Bio-Medical Engineering Departments in various Universities, the authorities should have the will and genuine interest of the Country at heart and take a positive decision even at this time of economic survival. This is a matter that concerns human health and where there is a will there is a way.

IN CONCLUSION OF THE MATTER

Mr. Vice-Chancellor, Sir, I believe that I am done. I have tried to show that engineering is not an exact science and that the game of the profession is to systematically combine theory with practice. It comes out clearly that it is a profession where both brain and brawn are utilized, with the brain directing the hand and that some of the engineers' functions can best be performed in air-conditioned offices. If what I have said aroused in you an admiration for the profession, my task would have been accomplished.

I commend to my professional colleagues the diligence and dedication of our predecessors, the master craftsmen of old, which was appreciated in the Old testament - New English Version of the Holy Bible with Apocrypha:

"So it is with every craftsman or designer who works by night as well as by day, such as those who make engravings and signets rings and patiently vary the design; they concentrate on making an exact representation, and sit up late to finish their task. All these rely on their hands, each is skilful at his own craft. Without them a city would have no inhabitants; no settlers or travellers would come to it. Yet they are not in demand at public discussions or prominent in the assembly".

As it was written, so it almost is today. Engineers are rarely heard in the corridors of political power because they concentrate mainly on their work; to make the cities viable and pleasant to live.

I quote from the New International Version of Ecclestiates Chapter 12 verses 9 - 14:

"Not only was the Teacher wise, but also he imparted knowledge to the people. He pondered and searched out and set in order many proverbs. The teacher searched to find just the right words, and what he wrote was upright and true. The words of the wise are like goads, their collected sayings like firmly embedded nails - given by one shepherd. Be warned, my son of anything in addition to them. Of making many books there is no end, and much study wearies the body. Now, all had been heard here is the conclusion of the matter: Fear God and keep His Commandments for this is the whole duty of man. For God will bring every deed into judgement, including every hidden thing whether it is good or evil."

Mr. Vice-Chancellor, sir, the Deputy Vice-Chancellors, the Registrar, other Principal Officers, Professors and members of Senate, Ladies and Gentlemen, I thank you very much for listening and I hope that I did not bore you. This is my Ebenezer. I hereby rest my case.

ACKNOWLEDGEMENT

My gratitude to the Almighty God for saving my life on the 24th January, 1996, when I had what is known in the Medical parlance as temporary seizure for about six hours.

My gratitude goes to Professor Seggei Yuri Tanko Timochenko of the Moscow Electrical Institute of Technology, who actually opened my eyes to the abstraction of Electrical Engineering with all the fundamentals entailed in Electrical and Electronics Engineering especially Automatic Control and Systems Engineering in the 1960s.

My thanks also to Professors Nicholas DeClaris and Robert W. Newcomb, both of the Department of Electrical Engineering of the College of Engineering, University of Maryland, College Park-Campus, Maryland, U.S.A. for their roles and immense contributions that plunged me into a then very new and innovative area of discipline in Electrical/ Electronics Engineering - Bio-Medical Engineering.

To Chief Gabriel Otunla, my Physics and Chemistry teacher at the Baptist Boys' High School, Abeokuta and former President of National Conference of all Principals of Secondary Schools and Chiefs A. Akinola and I. Adepoju, my Mathematics teachers at the Baptist Boys' High School Abeokuta and Mr. Henwoood, my Pure and Applied Mathematics teacher, and also to Chiefs Dotun and Femi Oyewole, who actually nurtured me with their wealth of knowledge and experience in Physics and Chemistry at Abeokuta Grammar School.

To Dr. Olusegun Ajayi (popularly known as Dr. Buba by the students in the Faculty of Engineering) for the inspiration he has given to me. Unknown to him, I have heard of him since 1959 when he and a senior of mine at the Baptist Boys High School Abeokuta - Prof.

Gbolagunte Ajao of UCH, took at Abeokuta Grammar School, the Higher School Certificate Examination in December, 1959 and performed so excellently well that they obtained 3 distinctions in Pure Mathematics, Applied Mathematics and Physics; and in Biology, Chemistry and Physics respectively. It was the talk of the town in March, 1960. He later went to University of London to a obtain First Class Division Honours degree (B.Sc. (Hons.)) in Electrical Engineering. With my coming to the University of Lagos in October 1970 as an Assistant Lecturer in the Department of Electrical Engineering (and he was a Lecturer II) he gave me all necessary encouragements to stay. He is a great scholar and teacher who spent hours upon hours in the Machines Laboratory, teaching the students about all the minute details of Power Systems and High Voltage Engineering. In fact, he was able to persuade me to stay when I was given lucrative appointments by the Gulf Oil Company (Now Chevron Nigeria Unlimited) and the Nigerian Breweries. Mr. Vice-Chancellor Sir, I believe that the University of Lagos through the Welfare Board should introduce a long years (say 15, 20, 25, 30 and 35 years) and meritorious services awards incentive to honour our deserving staff of the University of Lagos. If this is done, people like Dr. Olusegun Ajayi, the past president of the Nigerian Society of Engineers and past Chairman of the Electrical Division of N.S.E. who served this University from 1968 to 1992 will have his name deservedly recorded in the history of this University and in particular in that of the Department of Electrical Engineering as a great scholar worthy of emulation.

To the city of Abeokuta, a citadel of learning where Abeokuta Grammar School (founded in 1908) and Baptist Boys' High School (*Nulli Secundus* (second to none)) (founded in 1923) are situated. I had all my primary and secondary education in this city.

To the Vice-Chancellor and the University Administration for the financial support towards this inaugural lecture and various staff of the University, who contributed in no small measure to the success of this lecture.

To my senior brothers Hon. Olugbolahan Ijaola and Mr. Olufolajin Ijaola who had monitored my progress from the cradle.

To my mother, Chief (Madam) Emily Mosunmola Ijaola over 90 years of age, who despite the fact that she has never had any formal education, cherishes and admires the beauty of sound education.

The role of my late father - Chief Samuel Okewole Ijaola who gave me the strong informative foundation in Mathematics at a very tender age through his use of "Pendubury Arithmetic". May his soul rest in perfect peace.

To my late wife, Mrs. Florence Modupeola Ijaola, who died prematurely in LUTH on 22nd February, 1980, after protracted illness. She laboured hard with me in U.S.A. but unfortunately, she was not to live to enjoy the fruits of her labour. May her soul rest in perfect peace Amen.

To my children; Olurotimi Ijaola, a medical doctor, who worked with me during the preparation of my inaugural lecture; Miss Oluyomi Ijaola; Mr. Olusegun Ijaola and Master Oluseun Ijaola, who had cooperated with me in spite of all odds of life. I say thank you all.

To my wife - Mrs. Deborah Omolara Ijaola for standing by my side during the turbulent periods of my life.

DEDICATION

Dedicated to the memory of my beloved Father and mentor late Chief Samuel Okewola Ijaola, Ex-Senior Station Master, Nigerian Railway Corporation and Ex-Seriki of Egbaland Christians in ABEOKUTA. He seriously shaped my future very early in life.

Chief S.O. Ijaola

Also to my mother Chief (Madam) Emily Mosunmola Ijaola, who despite the fact that she did not step into any school for formal education has moulded my life and encouraged me to move ahead, regardless of the frustrations, tribulations and perils that human life may bring about.

Chief (Madam) E.M. Ijaola

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