Portland Public Schools Geocultural Baseline Essay Series

African and African-American Contributions to Science and Technology

by
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Biographical Sketch of the Author

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"New conditions and new ideas juxtaposed with the ever expanding human consciousness experience-pool, may alter slightly or sometimes radically the boundaries of human experience; yet, as tomorrow's uncertainties become today's challenges, one thing remains constant -each new generation is creating its present on the transmaterial ground of a broad base of thoughts and accomplishments of its unknown African past "

- Hunter Havelin Adams, III, 1986

PREFACE

Philosphers have long noted that science is deeply embedded in human nature, but what is science? Science is the search for unity and wholeness within the totality of human experience. It is the process of investigation of different phenomena - physical, chemical, ecological, biological, behavioral, cultural, economic, and even spiritual. In this process is everything that the investigator does:

- Selection of phenomena to be investigated
- Development of paradigms or models or metaphors
- Selection of the types of questions to be asked
- Selection of the appropriate methodology
- Choice of instrumentation
- Delineation of protocol and its execution
- Assessment of the certainty or uncertainty of the results

Yet this process of investigation, called science, is not value neutral; nor is it culturally independent; furthermore, there can be no ultimate objectivity. Why is this so, when neutrality and objectivity are believed to be an inherent and defining feature of science? Well, as California State University, theoretical social psychologist, Wade Nobles, points out, "science is the formal reconstruction or representation of a people's shared set of systematic and the cumulative ideas, beliefs, and knowledge stemming from their culture."[1]

It then follows that (as Ruth Bleier, science historian at University of Wisconsin writes in her book, **Feminist Approaches to** Science, **1986),** "The dominant categories of

cultural experience- race, gender, religion, and class will be reflected in the cultural institution of science itself: in its structure, theories, concepts, values, ideologies and practices. As human beings we all have deep-seated beliefs on most important issues and when such issues, like gender or race differences, become the subject of scientific investigation, scientists are not magically capable of suspending belief and judgment in their approach to the problem."

Nevertheless, as Prince Louis de Broglie, one of the founders of quantum physics, points out in his book **Physics and Microphysics** (1955), "many scientists of the present day, victims of an ingenuous realism, almost without perceiving it, have adopted a certain metaphysics of a (sexist), materialistic, and mechanistic character and have regarded it as the very expression of scientific truth. One of the great services that the recent evolution of physics has rendered contemporary thought is that it has destroyed this simplified metaphysics, and with the same stroke has caused certain traditional philosophical problems to be considered in an entirely new light."

Perhaps the most important problem is this: What role does our consciousness as individuals - male and female and of different cultures - play in this processscientific investigation? First, by consciousness, we mean all categories of humanexperience-processing, including perception, cognition, intuition, instinct, and emotion at all levels, including those commonly termed "superconscious," "conscious," "subconscious" or "unconscious." In this light, the common concepts of mathematics; of physical theories such as mass, momentum, and energy; electric charge and magnetic field; the quantum wave function; entropy; distance and time; and even myth, are actually no more than

useful organizing strategies our consciousness has developed for ordering the chaos of information it receives from its environment. And as such, these concepts reflect as much of the characteristics of consciousness as they do its environment and more precisely, they reflect the characteristics of our consciousness interacting with its environment - for it is only through that interaction that reality is construed.

From this perspective, we can now understand that the very purpose of any physical and moreover any psychological theory is to order and correlate the tangible experiences of our consciousness within its environment, both physical and transphysical, in which it is immersed, to discover meaning. Furthermore, at a profoundly deeper level, all these concepts actually are representative of the nature and process of an individual or collective consciousness perceiving itself.

The point here is that, as Werner Heisenberg (co-developer of quantum physics) writes when he addresses this issue in his book **Physics and Beyond: Encounters and Conversations,** 1971, "We have to remember that what we observe is not Nature in itself but Nature exposed to our method of questioning." And it is in this vastly larger context we re-vision here, the significance of the contributions of African people to science and technology- recognizing, each of us-all people in fact- not only are scientists, but, at a more fundamental level, science itself.

INTRODUCTION

A recent National Science Foundation report, **Science and Engineering Education for the 1980's and Beyond,** warned that important national decisions involving science and technology will be made increasingly on the basis of ignorance and misunderstanding because of a trend toward virtual scientific and technological illiteracy in the population at large.

To meet this challenge, the report outlined strategies to help the educational system. The most critical need is the development of curricula to engage the interests of students of average ability and less and also those who are alienated from science and mathematics, particularly minorities.[2]

Deanna Banks Beane of American University in Washington, D.C. and the National Urban Coalition, points out in **Mathematics and Science: Critical Filters for the Future**[3] that while many major efforts are now being made to generate and heighten interest in mathematics and science among all pre-college students, encouraging, even requiring them to take more mathematics and science courses, **a significant number of minority students,** for a host of reasons, **are still losing out.**

Among them, for example, are classroom factors - teacher expectations and instructional practices and for students, there are cognitive and affective factors. Evidence suggests that many African, Hispanic, and Native American students' general non-interest in science and mathematics may in part be due to racial stereotypes - that is, those students may perceive these subject areas as white domains and thus totally unrelated to their world of experiences. The skills to be acquired have no perceived utility. Heavily contributing to this false perception is the absence of positive role models of themselves as a group in those fields. Thus, it is difficult for students to visualize a future for themselves in science or technology. Making matters even worse is the systematic exclusion of, for example, African peoples' scientific discovery, knowledge, and invention from the curriculum.

This is documented in the ongoing research of Professor of Physics at the University of Illinois in Chicago, John Pappademos, who made a 1979-80 survey of currently used high school and college physics textbooks. He found that:

> "A whole continent (Africa) is deleted from the history of physics. In all 17 books surveyed, not once is a scientific discovery or discoverer identified as being of African origin. No Black scientist is pictured in any of the books, nor is a single Black scientist credited with any contribution."[4]

Thus, we are led to believe that Black people have contributed absolutely nothing in the field of physics and at a more fundamental level as Harvard Professor Arnold Toynbee arrogantly exclaims in his book **The Study of History:**

> "When we classify mankind by color, the only one of the primary races ... which has not made a [single] creative contribution to any of our twenty-one civilizations is the black race ..."

Stop and think a moment; doesn't it really seem a bit strange that African people did not have, nor employ, knowledge of the natural sciences, but nevertheless survived the contingencies of Nature as individuals as well as groups - including EuroAfricans for the past four million years? Consider this, survival was/is based on, for example, one's ability to read weather patterns, to develop ways of helping wounds to heal better, to find a diet balanced in essential nutrients, and to pass on to succeeding generations that knowledge.

Well, the truth of the matter is that there is a rich history of African scientific knowledge, discovery, and invention that predates the dawn of European civilization; in fact, if the question were asked as to what the greatest achievements of humanity are, no answer could rival (in importance and impact) the discovery of **time,** the control and use of **fire,** the development of **tool technology, language,** and **agriculture.** Nothing in the 20th century has touched humanity so totally as those things which were first accomplished by Africans - not landing on the moon, the discovery of DNA or nuclear energy, television or lasers, nor even the automobile - nothing.

The tragic irony is that texts like Toynbee's have become classics in Humanities courses in colleges worldwide, carrying to generation after generation of fertile minds the myth of the superiority of the European contributions to human history and the superiority of the present period to ancient and medieval periods of human history. An evidence of this is the widespread use of negative-value latent terms like "primitive" or "savage" or "undeveloped" as catch-all descriptors of African, Asian and other traditional cultures.

The upshot of this is, by no fault of their own, African people's scientific and technological contributions have been placed in almost an hermetically sealed vault, or diminished in significance or even worse, their African identity has been misrepresented. **What is long overdue and now sorely needed is a more balanced view of science history, of human history, but where do we begin?**

Professor Beane's research findings offer us an answer: in order to break this cycle of cultural chauvanism, to build positive attitudes (among all students and teachers), to destroy stereotypical images and help minority students develop a strong academic concept while mastering the basic concepts and skills in mathematics and science, the most effective place to intervene is in the elementary school (notwithstanding, of course, high school and college).

The goal of this essay is to address this, as will be seen, glaring omission by giving a very brief chronological survey of selected contributions by African and African-Americans to science.

PART I - HUMAN BEGINNINGS AND AFRICAN CONTRIBUTIONS TO SCIENCE

HUMAN BEGINNINGS

Around 3.8 - 2.8 million years ago, in the virgin rain forests of East Africa's valley of the Mountains of the Moons, where the Great Lakes gave birth to the River Nile, humans, first as Australopithecus Afarensis, began their odyssey on earth. During this early phase of human existence, nature innately provided humans with all the knowledge necessary for living in perfect harmony with the world.

As the millennia passed, humans experienced a series of physical, behavioral and cultural transformations as the face and climate of the earth changed. The environmental stresses forced people, called Homo Habilius, 2.3 - 1.6 million years ago, to venture beyond the security of the fertile rain forests into the new unsettling conditions of semi-arid open savannas and sparse woodlands. The evidence of this are the finds by the paleoanthropologist, Donald Johanson, of hominidae fossils in Ethiopia which he calls "Lucy" and the "First Family."[5]

MAN DEVELOPS FIRST TOOLS, LANGUAGE, DISCOVERY OF TIME

From the above-noted transition occurred two of the most catalyzing events in the development of human consciousness. Science writer Boyce Rensberger points out that the patchy and obscure distribution of food put a premium on intellect and led to the invention of the first tools [Fig. 1]: digging sticks to get at the savanna's roots and tubers, and baskets or bags for carrying a day's haul back to home base.[6] The home base might have been little more than a shady spot by a stream, but the implications are enormous - African people had already developed a stable social organization and a high level of cooperation.

Furthermore, intrinsic to the process of making tools is the perception of three temporal modalities: past, present, and future. Imagine Homo Habilius making axes, envisioning future occasions when they would be used, and in shaping stones recalling past experience of axes and how best to use them. Planning helped our early ancestors insure that when the need arose, they would be equipped with a tool or weapon that would enhance their prospects for

survival. Yet Homo Habilius probably did not see from life's experiences the need to see tool-making as being divided into separate temporal modalities. Those ancient people lived as many people do today, in the dynamic present - in the midst of a simultaneous past, present, and future.

MAN DISCOVERS FIRE

In time, Homo Habilius became Homo Erectus, 1.6-0.4 million years ago. Lightning and seemingly random celestial events, comets, meteor showers, eclipses, and exploding stars and perhaps the new taste of forest fire "naturally" cooked meat kindled in his consciousness a greater, deeper importance of, one of Nature's greatest mysteries - fire. Homo Erectus realized a relationship between life, the sun and fire, and soon they learned to control and use it for warmth on cool nights and now the cooking of food.

PROTO BEGINNINGS OF ASTRONOMY

As Homo Erectus moved up the Nile Valley and ventured into virgin Southern Europe, China, and Java, with a more-developed tool technology, Homo Erectus became even more aware of the rhythms of the summer's heat and the winter's cold, of the light and the night, and gradually began to focus attention on the awesome spectacle of the heaven's glory. During these periods, 400,000 - 100,000 years ago, in which Homo Erectus slowly became Homo Sapiens, there was a further expansion of our ancient foreparents' space-time/self-consciousness.[8] Homo Sapiens discovered that this sense of time had a debit side: humans had to pay a price for this faculty that

had enabled them to successfully survive the contingencies that threatened their physical well-being and also improved the material conditions of life: that price was the knowledge of mortality. Because of this ability to look forward in time, **every person** anticipates his physical disintegration and personal extinction. The irony is that few people, even today, accepts consciously in his daily life the inevitable movement toward death.

Each and every one of the critical transformations of human culture, including the last one from Homo Sapiens to Homo Sapiens Sapiens, 280,000 years ago to the present, is associated with the cycles of the great celestial harmony and profound climatic changes which then affected the ecosystem during those times. Furthermore, Allan C. Wilson, a professor of biochemistry at the University of California at Berkeley and Rebecca L. Cann, a geneticist at the University of Hawaii, in their recent study of patterns of human genetic diversity establish that the transition from Homo Sapiens to Homo Sapiens Sapiens (contemporary humans) first occurred in Africa and not in Europe.[9]

BEGINNINGS OF SPIRITUAL SCIENCE: PSYCHOLOGY AND RELIGION

The late Pleistocene period, 160,000-30,000 years ago, marked the beginnings of the mysterious ritual burial of the dead. This quantum leap in human consciousness was probably precipitated by a combination of terrestrial and celestial events. These occurrences indelibly imprinted on the human mind that death was no longer realized as the absolute end of life, but the beginning of a new phase of life. Time now took on a different meaning.

EVIDENCE OF BEGINNINGS OF GEOLOGICAL SCIENCE

This period also marks the beginning of the mining of different minerals. In 1982 the first evidence was found that showed Upper Paleolithic people initially mined chert, a cryptocrystalline quartz mineral at a 33,000-year-old site called Nazlet Khater in Upper (Central) Egypt located about 250 km. northeast of Luxor. The authors, P.M. Vermeersch, et. al, report that the extraction techniques were so complex that they revealed the Nile Valley paleolithic people as having had considerable geological insight.[10] Historian Yosef Ben Jochannan describes in his book, **Africa: Mother of Civilization,** the evidence of extensive copper and iron mining in Southern Africa during this period and also iron mining in Zimbabwe about 5,000 years ago.[11]

FIRST STEPS TOWARD MEDICINE

Guido Majno in his classic work, **The Healing Hand: Man and Wound in the Ancient World,** suggests that the treatment of wounds and the diagnosis of illnesses in earnest probably began 400,000 - 30,000 years ago. He points out that although Nature is well-prepared to deal with the three major medical problems resulting from a wound: mechanical disruption, bleeding, and infection - man can aid this process even with very simple means.[12]

Majno argues that the stitching of wounds with plant fibers or even shreds of tendon, the pinning together of the lips of a wound with a thorn or spike used like a skewer with its protruding ends tied together with fibers, and the use of insect mandibles as clips were probably used to some degree by Homo Sapiens. He

also says it was likely that early man performed other forms of medical aid such as eye and dental diagnosis, especially since chimpanzees in captivity have been known to do so.

FIRST SYMBOLIC WRITING, MATHEMATICS AND CALENDRICAL NOTATION

The Pleistocene epoch also marks the appearance of the first engraved rocks and tools in Africa. From these engravings we can infer, as Thompson notes, that "Humanity crosses another threshold, miniaturizes its universe into symbolic form, and takes a toddling step toward iconography, writing, and the first stammerings of calendrical notation and mathematics."[13]

SCIENCE, TECHNOLOGY AND INVENTION IN THE NILE VALLEY

Beginnings of Agricultural Science

Around 18,000 years ago, the women of the Nile Valley transformed food gathering into gardening at a southern Egypt site called Wadi Kubbaniya, which is near Aswan. These African women also developed a more accurate lunar calendar using the moon's occultations with a number of different stars to keep a running record of the passage of time and seasons. Their observations guided them in planting and harvesting, as well as in scheduling their various rituals and even in family planning - for they had discovered a lunar cycle/menstrual cycle relationship.[14] Alexander Marshack offers convincing evidence that many notations of Paleolithic man, found on cave walls and rocks, from the Nile Valley to southern Europe, represent lunar calendars. Between 11,000 and 7,000 years before the present, Africans had developed new tool technologies, built granaries to store the harvest, and began the

domestication of animals. This led to a decrease in hunting activities and an expansion of trading activities with other villages. All these activities marked the proto beginnings of agricultural science.

Development of Written Symbolic Language and Art Works

During this period, Africans also developed a written symbolic language to communicate their thoughts, experiences, and knowledge to future generations. The early characters of language were largely based on natural phenomena and on inner images - phosphene patterns, or light patterns in the mind.

Phosphene designs, internal patterns of light, are common to all people and are brought about by pressure on the eyeball, fever, neural disease, migraine headaches, sleeplessness, magnetic fields, cosmic rays, and drugs, as well as intense flashes of light. Heinrich Kluver, a neurologist at the University of Chicago, has classified the most common forms. They include:

a) Grating, lattice, fretwork, filigree, honeycomb, chessboard
b) Cobweb
c) Tunnel, funnel, cone or vessel
d) Concentric circles or spirals

More complex images may appear, such as whirling sunbursts, pulsating stars, flowers, and an ever-changing mixture of the primary phosphene forms.[15] These phosphene designs and other forms of visual imagery appear on rocks, cave and temple walls, pottery, and textiles, usually in the form of pictographs, petroglyphs, hieroglyphs and ideograms.

Development of the First Paradigms

In order to really appreciate the science and technological achievements of African people we must know and understand their mind-set; how do they perceive and conceive reality? What is the nature of knowledge? How does one know?

After the Sahara had become a desert, around 6,000 years ago, more people migrated to areas adjacent to the Nile River, forming towns [Fig. 2]. Yet even prior to the earliest pre-dynastic cities such as Nagada and Hierakonpolis (5,100 years ago), a principle of Divine Order had governed all the people of the Nile Valley, from the Great Lakes of Central Africa to the Nile Delta on the Mediterranean Sea. This principle came to be known as Maat. Jacob Carruthers of Northeastern Illinois University and Director of the Kemetic Institute explains:

> "Maat is the principle of balance in the universe _ whether that balance refers to weights and measures in the market, law in the courts, the judgment of the dead or universal cosmological patterns."[16]

Additionally, former Director of Egyptology at the University of Leipzig, Seigfried Morenz, states:

> "Maat is right order in Nature and society, as established by the act of creation, hence means according to context what is right, what is correct. This state of righteousness needs to be preserved or established in all matters great and small. Maat is therefore not only right order but also the object of human activity. Maat is both the task which man sets himself and also, as righteousness, the promise and reward which await him on fulfilling it."[17]

Moreover, Lucy Lamy points out in her book, **Egyptian Mysteries:**

> "Maat is Cosmic Consciousness, the ultimate goal of Creation and of every creature, the immortal fruit of a constant acquisition. Maat is the greatest treasure that a being might wish for."[18]

This is beautifully expressed in the following brief extract from the Berlin Papyrus:

> ... Maat is in every place that is yours ... You rise with Maat, you live with Maat, you join your limbs to Maat. . . the divine entities reward you with Maat, for they know her wisdom ... Your right eye is Maat, your left eye is Maat ... your flesh, your members are Maat ... the breaths of your nose are Maat ... you exist because Maat exists ...

As we can see, man did not establish Maat, man discovered Maat; Carruthers further notes that Maat originated at what the Egyptians call the "first time." The moment the Creator, they call Neter Ua Ua (One God without a second), created itself from the pre-beginning, non-material condition of a primeval ocean of spacelessness, boundlessness, and formlessness they called Nun [Fig. 3].[19] This concept called Maat represents the first set of scientific paradigms: A set of general principles which serve as the basis from which the ancient Egyptians did all types of scientific investigations. Let us take a cursory examination of a few of the most fundamental ones.

1. ACKNOWLEDGEMENT OF A SUPREME CONSCIOUSNESS OR CREATIVE FORCE

The Egyptians notwithstanding, most African peoples' lives were and are, even today despite the influence of secular materialism or Marxism, ritualized about the adoration and service of some Supreme Consciousness or Creative Force.

2. EXISTENCE VIA DIVINE SELF-ORGANIZATION

From being co-conscious with Nature, they readily saw the relationship between all living things. Creation is a dynamic ongoing process, yet God is the evolver of all things, not chance. As Einstein said, "God doesn't play dice with the universe."

3. A LIVING UNIVERSE

To the Egyptians, the entire cosmos is a unity, a living entity, and as such, everything is alive. All things are related either directly or indirectly, and furthermore, everything is affected by everything else.

4. MAN/LIFE ITSELF IS A MYSTERY

African people see life as the Creator's supreme mystery: they accepted the fact that their knowledge was limited, and would always be so (eons before Kant). Yet they devoted their entire lives, generation after generation, towards understanding life and life after life, with the goal of the unfoldment of man's Divine life.

5. MATERIAL & TRANSMATERIAL CAUSE AND EFFECT

Africans search for understanding the nature of things, led them to discover beyond the material cause-and-effect relationships, the hidden yet more pervasive transmaterial ones - information and even one's own thoughts and emotions.

6. CONSCIOUSNESS SURVIVES DISSOLUTION OF THE BODY

The Egyptians knew that consciousness, the thread that connects everything, is a - continuum, existing before, with and after material things-"from everlastingness to everlastingness," thus man, transphysical man lives in eternity. For the Egyptian, death as opposed to life, did not exist in his or her mind. Their language had no icon to express it. To them, death was nothing but a further step in life or another dimension of life.

7. NATURE OF KNOWLEDGE: EMPHASIS ON INNER EXPERIENCES

From the world-view of Africans, there are many realities beyond the five primary senses. Learning is a holistic process, through symbolic imagery and rhythm, with a lot of attention given to inner experiences and the process of thought. Africans understood the multidimensionality of the mind: logical/rational, intuitive/ symbolic, and emotional/spiritual. Well, the beauty, the wholeness, of this educational approach is being rediscovered and implemented today, in corporate as well as educational settings.

8. MORAL, ETHICAL, AND SPIRITUAL VALUES THE PREREQUISITE FOR SCIENCE EDUCATION

Training to be a priest/scientist in Egypt was a long, arduous process; learning was life-long. Also, since learning was in essence the discovery of Maat, the Egyptian priest/scientist was accountable to God as well as his/her peers. For the ancient Egyptians as well as contemporary Africans world-wide, there is no distinction and thus no separation between science and religion.

Furthermore, contrary to scientific development under Islam or Christianity where women were (and in some cases still are) discouraged from pursuing higher levels of knowledge, African women in Egypt were encouraged to do so. Not only in writings, but in art as well, we find Egyptian women depicted as intelligent, innovative, co-independent in leadership in a host of aspects of their society and in complete control of herself, the home, and the family's future. For example, early in Egypt's history (about 2700 B.C.E.), we learn of a woman scientist, chief physician Merit Ptah. In fact, the last great scientist of antiquity was an Afro-Greek woman mathematician, astronomer and physicist named Hypatia who lived in Alexandria, Egypt about 400 A.D.

From this cursory examination of the fundamental science paradigms of the ancient Egyptians, we can see that they are antithetical to contemporary Western ones. This is not to say that individual Western scientists do not share some or all of the beliefs of the ancient Egyptians, but that many Western scientists conduct their process of science from a totally different ideological basis, one which has, as its "main concern," non-ethical considerations such as cost effectiveness.[20]

ANCIENT NILE VALLEY HYDRAULIC TECHNOLOGY

"They come, the waters of life which are in the sky,
They come, the waters of life which are in the earth ...
The sky is aflame for you, the earth trembles for you,
before the divine birth of Osiris-Nile."

(Third Dynasty Pyramid texts of Unas [2063]).

This profound statement symbolically speaks to the ancient Egyptian people's

recognition that the river Nile was the umbilical cord that annually deposited the nutrient-laden, life-regenerating, alluvial earth from the womb of the world, the Great Lakes/Mountains of the Moon region near the equator, all throughout the valley. Moreover, it indicates the ancient Egyptians' belief of a celestial source of the Nile River. Supporting their extra-terrestrial origin of the Nile theory, evidence has been recently found showing that the earth today and for hundreds of millions of years, has been inundated by water-laden micro-comets, which not only over time were the source of the ocean's water, but of rivers' water like the Nile.

To the hearts and minds of the ancient Egyptian people, the river Nile, the bringer of fertile soils, was venerated as the god Hapi. Hapi represents the river Nile's celestial connection. Hapi is generally depicted as a male god by the classic long beard, yet he has one large breast, symbolic of the Nile's feminine nature, as the source of life-giving nourishment. On top of his head is either a grid pattern that symbolizes the extensive irrigation networks along the Nile ora number of lotus flowers (water lilies).

Prior to the dynastic era, the agricultural practices of the ancient Egyptians were based on natural irrigation; that is, the water flowed without any artificial diversion. Nathan Kamau Anderson,[21] a hydraulic engineer with the U.S. Army Corp of Engineers in Portland, Oregon, points out that as the population density increased, there was a subsequent need for increased agricultural production which natural irrigation alone could not support. Thus, canal irrigation was developed during the latter part of the pre-dynastic period.

Under the reign of the first pharaoh, Menes, also known as Narmer, hydraulic projects dramatically increased. The scope of hydraulic projects took on greater proportions with the beginning of pyramid-building around the Third Dynasty of Pharaoh Zoser. Anderson further notes that there is evidence of quarried stone revetments, canals, large piers, and artificial lake basins along the desert edge between Giza and Abu Sir. These hydraulic projects were used to regulate the flood waters for transportation of construction materials for the pyramids of Pharaoh Khufu, Khafre, and Menkaure (Fourth Dynasty). The most significant hydraulic project undertaken during this early dynastic period was the construction of dams.

The most impressive of these dams from a hydraulic engineering perspective was the so-called Sadd EI-Kafara Dam located about 18 miles southwest of Cairo. Constructed approximately 4,600 years ago, it represents the first attempt at storing a large volume of water. The present name given to it by Arab invaders of Egypt means "dams of the unbelievers" (in Allah); the original Kemetic (Egyptian) name is presently unknown.

The purpose of the dam was to provide flood protection for the lower wadi and the Nile Valley. The dam's total width is 321 feet with a crest width of 179 feet, and its height was 47 feet. Over 200 million pounds of material was used in its construction. The dam's core contained materials with low impermeability with two rock-fill sections on both sides. Tragically, the dam, when about 95 percent complete, was destroyed by a catastrophic flash flood. If it had been finished when that flood came, it would have performed as designed and directed the flood waters over its spillway. Nevertheless, the method of construction used by the ancient Egyptian engineers set the standards for earth-fill dam construction over the millenia until today.

A. The Nilorneter: The First River Depth Gauge

During the First Dynasty, the ancient hydraulic engineers developed a device called a nilometer to measure the height of the Nile flood waters before, during, and after the annual inundation. The nilometer was the world's first river-depth gauge. They were placed strategically at various sites along the Nile because of differing flood levels in the valley. The difference in flood stages varied as much as 48 feet (28 cubits in Egyptian measures) at Elephantine in the far south, to10 feet (6 cubits) in the delta at the Great Sea (Mediterranean Sea) in the north.

The lifeways of the Kemetic (Egyptian) people were directly related to the readings taken from the various nilometers. The ancient Kemetic hydrologists used the nilometer to measure the amount of sediment that is transported in the river and the amount deposited in the floodplains. For example, nilometer readings were used to assess taxes and to forecast the degree of success or failure of the crops planted during the upcoming season. This is graphically illustrated by a commentary on a nilometer gauge at Memphis:

> "12 cubits would cause horrible famine,
> 13 cubits would bring security,
> 14 cubits would bring a fair season,
> 15 cubits would satisfy all,
> 16 cubits would produce unbounded transports of joy."

B. Water-Lifting Devices

In the early Dynastic periods, Anderson additionally points out, agricultural expansion was limited by the amount of cultivatable land that could be

irrigated by natural irrigation and artificial irrigation using canals. In order to meet the food demands of a growing populace, the Egyptian hydrologist, around 1340 B.C., developed a hydraulic-lift device called a shaduf to raise water to higher elevations, thereby increasing the amount of cultivatable land. This instrument is based on the principle of the lever, and was capable of lifting water about five feet. The baddala was another very low-lift device used in the Nile Valley fields to transfer water from one field to another. During the Ptolemaic period, around 300 B.C., a hydraulic device was invented called the saqiya. The saqiya was innovative in that it was a cattle- or oxen-driven device and was capable of lifting water well over 20 feet. The tambur, or the so-called Archimedes Screw, was used in the delta as a low-head hydraulic lift device. Archimedes took this device back to Europe and, subsequently received credit for its development though it was being used in Egypt prior to his arrival there. Both the shaduf and the saqiya are still being used today in the Nile Valley; however, they are gradually being replaced by the electric pump.

EGYPTIAN COSMOLOGY/TIME IN THE EGYPTIAN MIND

The drama of creation was replayed in a multitude of ways to the hearts and minds of the Egyptian people: the flooding and receding of the Nile, and daily sunrise and sunset, the scarab beetle's life cycle, and the star Sirius's heliacal rising cycle. As participants/observers in the theater of the birth/rebirth cycle of life, they developed a remarkably advanced cosmology. This is graphically depicted in the papyrus of Nesi-Amsu, a scribe in the Temple of Amen-Ra at Thebes, about 305 B.C.[22]

The papyrus contains a treatise on the Egyptian view of the origins of the universe and the genesis of gods, man, and animals called "The Book of Knowing the Evolutions (the becomings) of Ra (the creator sun god)." Here is a brief coherent excerpt from it:

> The words of Neb-er-ter who speaks concerning his coming into existence: "I am he who evolved himself under the form of god Khepra (scarab beetle), that was evolved at the "first time." I the evolver of evolutions, evolved myself from the primordial matter which I had made,... which has evolved multitudes of evolutions at their "first time." I was quite alone ... nothing existed (before me) ... I made all things ... There was no heaven, there was no earth; soil, animals, and reptiles were not in existence.) constructed their forms out of the undifferentiated watery-like matter (Nun) ... I found no place there upon which I could stand. By the strength which was in my will i laid the foundations (of things) in the form of the god Shu (space). I made for them every attribute they have and their offspring came into existence from the evolution of their births (children) ... I made all evolutions by means of that soul (ba) which I raised up from inertness out of the primordial watery matter (Nun)."

The text goes on to state how men and women were created from the tears of the eye of the god, Ra, and describes the 'becoming' of the rest of all existence. This work, though containing frequent repetitions and a number of variant readings, is nevertheless the most complete version of a much older work(s). Fragments or variants of it are found in many different texts and in different periods of Egyptian history, such as "The Law of Opposites", called the "Memphite Theology" by Egyptologists in the text of the Shabaka Stone (25th Dynasty, 800 B.C.). What is so significant about the above book is that it shows the Egyptians had a theory of species evolution at least 2,000 years before Charles Darwin developed his theory of species evolution.

More than any other ancient people, the Egyptians seem to focus a great deal of attention to the reckoning of time. They were the first to come to a very accurate determination of the true length of the natural year and to devise a calendar based on it. They were the first to divide the day and night into 12 hours each, and they were the first to make these hours equal. The world still uses the Egyptian calendar modified during the Roman rule of Egypt by Augustus Caesar and later Julius Caesar.

The Egyptians viewed time in two complimentary aspects: a cyclic one, which manifested itself to them in the regular repetition of the sun cycle, the scarab beetle's life cycle, and of the Nile River flooding cycle, the flourishing of crops and the metathorical death/rebirth cycle of Asaru (Osiris). From this they derived the 365-day year as a unit of time. The second aspect of time is expressed by the idea of time stretching linearly from the "first time" to infinity (chronologically speaking, to eternity).

Chicago computer scientist, Levia Hoppzallern, offers more valuable insights. To the Egyptians, he points out, time was a unit of energy expressed in the form of an entity or process that can be measured by its duration. Prior to an entity's or processes manifestation, its "time" does not exist. As such, they recognized that an entity or process exists in two states: Potential - a functional or trans-material existence before its "first time", and actual - its period of manifestation or duration from its "first time" until completion of its life cycle, its eternity. Thus each thing represents a unique dimension of time. Time was therefore multidimensional. In the "Book of Caverns" (Quererets), a phrase illustrates this:

> "Unin-nefer of the living who passes through millions of time dimensions."

These ideas alluded to in the text above, "The Book On Knowing the Evolutions of Ra," anticipate many of the philosophical aspects of quantum theory in contemporary physics [Fig. 3].

The Egyptian System of Measures

Livio Catullo Stecchini, history of science professor at Harvard University, in an exhaustive study, documents how all contemporary systems of measure are based on standards established by the Egyptians.[23] The Egyptian metrological system coordinated the standard of time -the speed of rotation of one or more points in the vault of heaven with the standard length -the "cubit" (0.523 meters, originally called the kush), with the standard for weight-the "qedet" (9 grams) and with the standard for volume -the "heqat" (4.5 liters). Thus the Egyptian measures of length, weight, volume, as well as time constituted a rational and organic system.

The Egyptian measurement system was septenary in nature, that is, based on the number 7 and its multiples. Septenary units proved to be convenient in practical reckoning. They also used a nondecimal system based on the number 11. By combining calculations by the factor of 7 and calculations by the factor 11, one could solve practically, a host of geometric problems involving irrational numbers J2, /3, and *TT.* For example, the circumference of a circle was computed as 22/7 of its diameter equalling 3+1/7 = 3.142857, a very good approximation of n-. Thus the number 7, they observed, was the key to the dimensions of Egypt itself and the link between the shape and structure of Egypt and the order in the universe.

It should be pointed out that the Egyptians had three different, though closely related linear measures (cubits) [Fig. 4]. The cubit known as the royal cubit was subdivided into 7 "palms"; each palm was in 4 sections making a total of 28 "digits". This was not an arbitrary invention, but a direct derivation from a "standardized" measure of the human forearm [Fig. 4b]. The "Memphis" or profane cubit was 24 "digits" or 5 "palms." The khe or geodetic cubit was approximately 1/10 of one minute of a degree latitude or longitude or 350 royal cubits.

Beyond their own culture, beyond their own time, the Egyptian linear measure, the cubit, has figured prominently - from the "Tabernacle" of Moses to Sir Issac Newton's development of his theory of gravitation, which he discusses in a rare paper called "A Dissertation Upon the Sacred Cubit of the Jews and the Cubits of Several Nations: In which, from the Dimensions of the Greatest Pyramid, as taken by John Greaves, the ancient Cubit of Memphis is Determined."

Measurement of weight was done with balances of various degrees of precision. First there was the balance consisting simply of two pans suspended by cords from each end of a rod with a cord at its center to support it; then there were two types of beam balances - each had an upright stand to support the beam for greater stability. One had a plumb line hung against a rectangular board attached to the beam; for greater precision the plumb line was replaced by a metal pointer. Weights were usually highly polished, cubic, rectangular, or dome-shaped stones made from granite or limestone. As with the cubit, there were three standards of weight, the "qedet" of 9.1 grams and the "qedet" of 9.11 grams. The third standard of weight was the feather of the god (divine principle) Maat. It was balanced against the heart of a deceased person to determine their level of righteousness they maintained throughout their life [Fig. 5].

Egyptian Astro Science [24]

A. The Earliest Instruments

The early proto-dynastic Egyptians used various features on the horizon, such as mountains, as reference points or foresights behind which they would observe the rising or setting of the sun, moon, and possibly the planets Venus and Mercury. A. Thom discovered from his study of megalithic astronomy in the British Isles that by using suitably distant natural foresights, a remarkable accuracy of two arc-minutes could be obtained. These observations would take place at a specified time and place all through the day and night. Soon, after hundreds and even thousands of years of observation, the mystery of the Great Harmony would begin to unfold. Yet each generation did not have to start from square one, for the accumulated knowledge was passed on to every successive generation.

The earliest instrument used by the Egyptians was a shadow stick (gnomon) called a "merket" [Figs. 6 and 7a] or "the measuring instrument," around 4000 B.C. It had a V-shaped slit cut in the top. The merkhet would be placed in the plane of the meridian, an imaginary line joining true north and south. The observer looked through the narrowest part of the slit at a plumb line, which was either hung from a type of scaffold or hand-held on the meridian. A star crossing the meridian would be observed with the eye, while the sun was watched by the shadows of the string in the center of its V-slit. Once finding the local meridian line, they would observe the size and the maximum shift in the locations of the sun's shadows from sunrise to sunset and from day to day. The hourly divisions of the day could then be established and the approximate moment when noon occurred could be determined.

Using the same principle as the merkhet, around 3100 B.C. the Egyptians constructed larger shadow clocks out of limestone columns called obelisks [Fig. 7]. The Washington Monument resembles the obelisks of ancient Egypt. With the larger shadows cast by obelisks, more accurate time measurements could be made not only at noon, but for the vernal and autumnal equinoxes on March 21 and September 21, respectively. These are days with equal hours of light and night. Precise measurements of the summer and winter solstices, June 21 and December 21, respectively, were also possible. On these days the sun seems to stand still, rising at the same point on the horizon as on the previous day. The Egyptians knew by simple deduction that if the sun and moon were spherical, then the Earth had to be also. Nevertheless, they proved that the Earth was spherical by comparing the lengths of the shadows cast by obelisks suitable distances apart. The obelisk was also a symbol of their sun god, Ra'.

The Egyptians also made the solar gate [Fig. 7e.] which was simply two vertical columns with a lintel across them with a plumb line suspended over its center. It stood in the court of a temple and at a specified distance. Directly north of it stood a shadow rod. Together the plumb line and the rod marked the meridian, and the two shadows cast by them would move like the hands of a clock from sunrise to sunset. At exactly noon the shadows would be two parallel lines, making the solar gate a more accurate instrument than a merkhet for determining noon. This is how they determined the ratiometric distance between the earth and the sun. With this knowledge they could find the distance ratios from Earth to the other planets. This is the method the Greeks, Pliny and Ptolemy, later used.

B. Star Clocks

Around 2150 B.C.E., the first "star clocks" appear on the inside of coffin lids. Numbered from right to left, as in the direction of the revolution of the earth, they were divided into 36 vertical segments on which the decanal stars' (three decanal stars in each zodiac sign dividing each sign into sky segment into ten degrees) circuit of the year were inscribed. Twelve horizontal segments corresponded to the 12 hours of the night, with each segment representing a 40-minute time period. This was because the rising of each decanal star shifts forward by 40 minutes in a period corresponding to 1/36th of a year, 'roughly every ten days. By the time of Amenophis III, 1400 B.C.E., the Egyptians had developed the clepsydrae, or water clocks [Fig. 6c], which more precisely marked hours of constant length. The external surfaces of these clocks were laid out inexactly the same way as some star clocks on tomb ceilings, such as the Ramesseum, and coffin lids. These clocks, which resembled flower pots, were outflow types and were primarily used at night. A small hole in the bottom allowed water to flow out into another similar, but smaller pot, at the same interval of time as the hourly rising of the decanal stars. There were also inflow types that were used to time events. Around 1000 B.C.E. they made a small, portable, horizontal shadow clock. We have inherited the legacy of Egyptian time keeping, the 24-hour day and the 365.24-day year.

As previously shown, the Egyptian "hour watchers"-(priests/astronomers) studied the night sky and the day sky with the verve of present day astronomers. They were the first people known to describe light's physical properties, such as refraction, as this statement from the Coffin Texts (S 80:30), strongly suggests:

> "It is I who make the sky light after darkness, my pleasant color is due to the air which goes forth after me from the mouth of Atum ..."

Egyptologist, R. 0. Flaulker, says that this sentence attributes the pleasant blue of the sky to the presence of air, conceived of as appearing blue when viewed in depth. Furthermore, there are drawings which allude to the knowledge of undulatory properties of light as diffraction and interference, and the particle/wave nature of light. In fact, they symbolically represented the changing quality of the night-light, day-light, or moonlight by associating a particular division of the night sky and the day sky with a certain deity.

C. Egyptian Calendars

The Egyptians had four calendars running simultaneously - a lunar or agricultural one, a natural or solar one, a civil or festival one, and a sidereal one based on the elapsed time measured by the passage of the star Sirius returning to the same point on the horizon each year. Their first lunar month began with the morning when the waning crescent of the old moon could no longer be seen just before sunrise. Their 360-day "natural" year divided naturally, following their seasons: four months of inundation, when the Nile overflowed its banks and deposited that precious silt, fertilizing the valley; four months of planting and growth; and four months of harvest and low waters.

Each month had three weeks of ten days each. Five special holy days, honoring the Neteru, the divine principles, were added to end their agricultural year to keep it in harmony with the solar year. To keep their calendars in harmony with

the seasons, they introduced a 13th (intercalary) month at two 3-year intervals. This resulted from their determination that a lunar month may vary in length from 29 to 30 days, thus 12 lunar months (354 days) are about 11 days short of the natural year of 365.24 days. Eventually, they developed a sidereal calendar based on the heliacal rising of the star Sirius which was used to regulate the intercalary month.

They also discovered through long-term observation of the lunar cycle that every 18.2 years the Nile would rise to its highest level, causing severe floods; furthermore, they found out that the Nile would reach its lowest level every 9.1 years, leaving less land available for irrigation and sometimes causing a severe drought. They then planned their agricultural activities accordingly. Evidence of this is found in their own texts and also in the Bible in the story of Joseph and his interpretation of the Pharaoh's dream, Genesis: 41.

Sirius, which has risen heliacally, does not remain on the horizon everyday, but due to-Earth's motion around the sun, each day rises a little earlier and thus a little higher in the sky by sunrise. The Egyptian "hour-watchers observed that another star, roughly every ten days, rising heliacally, replaces Sirius as the morning star. Over time they had chosen 36 stars, all of which closely approximated the behavior of Sirius: first, it must lie in a band south of and parallel to the ecliptic (the zodiacal belt) and it must remain invisible for 70 days. Their explanation was that the star "dies" and enters the underworld, a place they call Duat, to be purified. Duat is divided into 12 regions, one for each hour of the night. This explains the 70-day time period for mummification. In a similar manner, the sun spends the hours of night in Duat. This is also how the sky came to be divided into 36 equal segments called decans (ten segments).

The interval between one star's rising and the new star's rising would be an hour; observing this pattern over a ten-day interval, they discovered that there were 12 hours for the night.

After the 70 days of purification in Duat, the star is reborn. What is significant here is that the night sky and Duat, while both are areas of darkness, are in fact two different entities. The night sky or Shu, space, is the place where stars reside. Duat metaphorically could be likened to stellar nucleosynthesis, the process of a star's formation and regeneration. The Neter (god-principle) Nut, the Celestial Cow, symbolizes the nutritive character of the cosmic environment.

D. The Imperishable Stars, Planets, Zodiacs and Astrology

Next to Sirius and Orion, perhaps the most important group of stars in the Egyptian sky were the circumpolar stars, the" Northern Group of stars that never set. For that reason they called them the "Imperishable Stars" or "undying stars," and they were symbols of immortality. The most important stars in this group were called "Foreleg" [Figs. 9 and 11] or Bull, which corresponds to what we call the Big Dipper. Another one, though unidentified, was the female Hippopotamus.[25] They appear usually on the inside of coffin lids or tomb ceilings, as found in the tomb of Seti I.

All the planets were surely recognized and named long before the earliest presently known textual evidence. Anyone using "merkhets" could not fail to notice the five bright stars changing their positions among the fixed ones. When the planets were depicted on monuments, they were in two groups. The outer

three were Jupiter, Saturn, and Mars. The second group was made up of the inner planets, Venus and Mercury. What is important here is the order of the planets related to the importance of the function of the god-principle assigned to represent it. Textual evidence indicates that they were aware that the inner planets could be either a morning or an evening star [Fig. 10].

Although the first zodiacs, circular and linear types, on astronomical monuments did not occur in Egypt until the Greek period (325 B.C.E.) and the concept of the zodiac is Sumerian/Babylonian, some of the zodiacal constellations were important to Egyptians as early as the Old Kingdom dynasties, graphically illustrated in the Sphinx's form. It has the head of a lion (Leo), the body of a bull (Taurus), the tail of a scorpion (Scorpio) and the face of a man (Aquarius). Compositely, the Sphinx embodies their knowledge of the precession of the equinoxes.

Astropsychological treatises 'in Egypt are based on two types. There are those with predictions of lucky and unlucky days. Each of the days of the month and each month has a god assigned to it, and their combination on a person's birthday determines his/her life's disposition. Each of the gods are usually associated with a constellation. These texts appear in the middle of the second millennium B.C. Following the conquest of Egypt by the Persians in 525 B.C.E., a second type of astropsychological literature appeared which dealt with predictions of eclipses of the sun and moon. During the Roman period, about 500 years later, a number of Egyptian personal horoscopes turned up. They are primarily concerned with the date of birth and when the planets and the moon enter in the Zodiacal signs. It is not known if predictions were made using this information along with the lucky and unlucky day-type horoscopes.

The people of ancient Egypt, "Kemet" as they called it - the "The Black Land," have left us thousands of hieroglyphic inscriptions, and yet over a hundred years and hundreds of scholars devoting their lives to their translation, the essence of their meaning still eludes us. This is primarily because the ancient Egyptians' polyocular epistemology renders their written style of communication, multicontextural. That is to say, there is a high degree of simultaneity and spontaneity, and also rhythm and symbolic logic in their thought; for example, superimposed in a single image are many points of view and moments for time. For an "expert" unfamiliar with Egyptian lifeways, translation could give the antithesis of the author's original intent.

In this regard in matters pertaining to astronomy in particular, some scholars such as Otto Neugebauer of Brown University and Edwin Krupp, Director of the Griffith Observatory in Los Angeles, not understanding the Egyptian Holistic world-view, denigrate Egyptian achievements. Both men claim that although the sun, moon, planets, stars, and other astronomical phenomena were mentioned in texts, no mathematical astronomical treatises have been found. Thus they conclude that the Egyptians therefore did not systematically study and record their observations as did the Sumerians and Babylonians. For example, Krupp says the astronomy itself is only implied, and the monuments suggest Egyptian astronomy was a "lightweight science." Neugebauer goes so far as to assert, "Ancient science was the product of a very few men; and these few happened not to be Egyptians." Their cultural arrogance not only blinds them to the inherent practical nature of African peoples' scientific process, but their views are totally incorrect.

E. Astronomical Texts

The Egyptians had a corpus of astronomical knowledge - about 100 primarily astronomical texts have been found.

Toward the end of Ramesside rule in Egypt, about 1100 B.C., a scribe of the sacred books in the House of Life by the name of Amenope composed a catalog of the Universe to be made up of "heaven with its affairs, earth and what's in it, what the mountains belch forth, what is watered by the flood, all things upon which Ra' has shone, all that is grown on the back of the earth." He began his list with "sky," followed by "sun," "moon," and "stars." He then listed five constellations, only two of which can certainly be identified, those of "Orion," "Foreleg" (earlier "Adze", which corresponds to our Big Dipper), "Ape," "Giant," and (female) "hippopotamus." The same text which reveals Egyptian constellations names also gives their name for astronomer, "hour-watcher."

In one of the chambers in the Temple of Edfu called the Chamber of Writings, there is a catalog of 12 works carved on one of its walls. Four books dealing with the stars are mentioned-one regarding moving stars (planets), one about the conjunction of the sun and moon, and the other two respect to their risings. Another one mentioned is a bibliography - "The Book of All Writings of Works in Wood." Astronomical knowledge was additionally integrated into other knowledge domains: many of their religious, architectural, and town planning texts speak to the existence of astronomical treatises, technical terms, and archives, which in most cases were classified and not for public view or review; i.e., sacred texts. Many of these texts mention a neter (god) Seshat.

F. Astro-Architectural Aspects of the Goddess Seshat

The goddess Seshat [Fig. 12], the female counterpart to the Egyptian god Tjehuti or Thoth (Greek), the master of time and the originator of the sciences, is the "Head of the House of the Divine Books" (archives), the "Lady of Writing(s)". She has a scriptorium, a special writing room set aside for scribes. In all of these cases, her function is to mark the events, the life period of the king, to reckon all things on a palm stick: she is the enumerator.-She is the original One who organized writing at the beginning, and who began to write books among the goddesses.

Closely related to her function as the "Lady of Writing" is her being described as the "Lady of Builders." She is the one who usually performs the foundation ceremony ritual: "stretching the line/cord" (plotting a building's axis) and "spreading out the plannet" (by simple geometric projection, she stakes out the building design on the field [Figs. 13-16]). A reference from the Pyramid Texts (616b) describes her activity as "assembling the members"; i.e., assembling and articulating the elements of a structure. The cord has a two-fold function: to fix the orientation of the temple by direct observation of a celestial object; and, also to thereby lay out by simple geometry the sacred pattern of the temple itself. An inscription reads:

> "The Living God, the magnificent son of Asti, nourished by the sublime goddess (Hathor) in the temple, the sovereign of the country, stretches the rope in joy, with his glance toward the ak of the Bull's Foreleg (our Big Dipper constellation), he establishes the temple-house of the priestess at Denderah, as took place before."

After fixing the orientation upon the constellation of the Bull's Foreleg, the rope-fasteners found a line at right angles to it by means of creating a 3:4:5 triangle [Figs. 17a and b], and from that the ground plan for the whole temple was accurately measured. Thus, the form of the temple expressed a relationship between the earth, the heavens, and man [Fig. 18].

The foundation ceremony itself is precisely determined by astronomical calculations. Furthermore, astronomical calculations provide the basis for determining the appropriate moments when all important activities regarding a monument's construction are undertaken. Certainly, if the ancient Egyptians had written surveying and architectural procedures which were based on astronomical calculations, the procedures for making those and other astronomical calculations and observations were written also.

Seshat's emblem [Fig. 12], the seven-petaled radiating flower, has an astronomical as well as meteorological connotation to it. As previously mentioned, the Egyptian measurement system was based on the number 7 and its multiples. The standard unit of measure for length, the royal cubit, was subdivided into 7 "palms"; each palm was in 4 sections making a total of 28 "digits." Astronomically, the 7 petals of Seshat's emblem represents a monthly period of 28 days, parallel to the 28 digits. The superimposed hieroglyph of the crescent moon would represent the lunar month, complemented by 2 additional days represented by the 2 vertical appendages forms the regular 30-day month of the Egyptian calendar. The 7 petals may also symbolize the 7-pole star constellations and the 7 brightest stars in the constellation Pleiades. Her emblem appears on First Dynasty tablets and on the stelae of King Narmer, the one who unified Upper and Lower Egypt.

Seshat's lunar symbolism is very natural when we consider, as it was previously mentioned, that the women of the Nile Valley and elsewhere during Paleolithic times, over 33,000 years ago, became the first astronomers following their discovery of the correlation of their menstrual cycle with the lunar cycle. Alexander Marshack,[26] science historian at Harvard University, gives convincing evidence that marks found on paleolithic artifacts, rocks, and cave walls are mathematical and lunar cycle notations. His and P.M. Vermerrsch's findings further corroborate the remote beginnings of the organization of Egyptian religion, science, and government during the epoch of "The Companions of Horus" and even earlier, at least 40,000 years ago.

Architectual Texts, Technical Terms, and Archives

Alexander Badawy,[27] in his groundbreaking study of Egyptian architectural design, reports the existence of Egyptian archives. The texts relating to surveying, town planning, and architectural pursuits, speak for themselves as proof of the existence of archives.

After the troubled years of the First Intermediate Period of the middle kingdoms, Prince Khnumhotep II describes the work of his grandfather:

> "He established the southern landmark, perpetuating the northern like the heavens; he divided the great river (the Milky Way) along side its middle; its eastern side of the "Horizon of Horus," was as far as the eastern highland; at the coming of his majesty, when he cast out evil, shining like Atum himself, when he restored that which he found ruined; that which a city had taken from its neighbor; while he caused the city to know its

> boundary with the city establishing their landmarkers like the heavens, distinguishing their waters according to that which was in the writings, investigating according to what was old, because he greatly loved Maat (truth and justice)."[28]

From a stelae of King Neferhotep at Abydos, here is a passage describing his wish to seek original information from the archives about the "exact" original form of the statue of Osiris:

> "His majesty spoke to the nobles, and companions, who were in his suite, the real scribes of hieroglyphs, masters of all secrets: `My heart hath desired to seethe ancient writings of Atum; open you for me for a great investigation; let the god know concerning his creation, and the gods concerning their fashioning, their offerings and [their] obligations ... (let) me know the god in his form, that I may fashion him as he was formerly, when they made the [statues] in their council, in order to establish their monuments upon the Earth'."

He is now advised by his court:

> "Let thy majesty proceed to the libraries, and let thy majesty see every hieroglyph. His majesty proceeded to the library. His majesty opened the [leather] rolls together with these companions. Lo, his majesty found the rolls of the House of Osiris, First of the Westerners, Lord of Abydos."

Here the wish to comply with the early rules is clearly expressed. Rules could also assume the form of technical specifications or procedures and were kept secret among members of the craftsmen's guild, the hour-watchers, and other high officials. Also, many texts themselves emphasized secrecy had to be kept even while carrying out projects. This care for secrecy was aimed at keeping the tradition free from alteration and contamination which would have occurred had every initiate had

access to all the information. The main purpose of secrecy was to maintain the "rules of Old". Krupp, et al., to base their conclusions that the Egyptians did not systematically study and record the motions of the heavens, never considered known Old Kingdom references such as the ones previously mentioned, which support the existence of records and technical terms of heavenly bodies and phenomena.

To give some idea of how old these "rules of old" probably are, the Turin papyrus states that during the reign of King Narmer (Menes), the progenitor of the "historic" or dynastic period, there were Companions (or Servitors) of Heru (Greek, Horus), the Shemsu-Her, who had reigned for 13,420 years; and there were reigns before the Companions of Horus of 23,200 years. Not only does this establish that their religion, science, and art of writing were institutionalized at least 40,000 years ago, but additionally gives strong support to their knowledge of precession of equinoxes as revealed in the Denderah Zodiac of the Ptolemaic Procession period.

The Great Pyramid

The Egyptians saw their land as an image of the heavens. They incorporated this macrocosmic perspective in their monuments, temples, and pyramids. The Greek word pyramid is derived from the Egyptian word "per-em-us" which refers to the slope/height of the structure, not what it is. The Egyptian word for pyramid was "mer khut(i)," which means, "place of ascension into glorious light."

The pyramids were conceived to represent the northern celestial hemisphere on a flat projection. Each flat face of the pyramid thus represented one curved quadrant of

space. At Giza [Fig. 19], the Great Pyramid of the pharaoh Khufu (Fourth Dynasty, 2650 B.C.), which was called the "Slope of the Horizon of Khufu," is the greatest example of this. The four sides of its base were oriented almost perfectly toward the astronomical cardinal directions; north, south, east, and west. Orientation is an important part in the planning of almost every building, whether it be a solar home positioned to maximize sun exposure or an observatory located to get the best possible view of the night sky.

The 756-foot-per-side base of the Great Pyramid is practically a perfect square. Its four sides are inclined at an angle of 51 ° 51' 14.3" reaching a height of 481.4 feet. The Egyptian master construction engineers used approximately 2.3 million limestone and granite blocks of stone to construct it. They weighed, on the average, 3,000 pounds each, although some weighed up to 32,000 pounds. The rough cut limestone blocks which comprise the bulk of the pyramid were once covered with highly reflective white tura limestone. When sunlight hit the brilliant surface of the geometrically perfect pyramid's white limestone casing, the whole structure seemed to glow bright white.

Inside the Great Pyramid is an enigmatic series of passages [Fig. 20] and three chambers, the largest of them the "King's chamber," containing only an empty granite sarcophagus. It has two shafts, one on each side of the room and about nine inches square, which pass through the structure to the outside, included such that the north-facing one at a 31° angle was centered within one degree of accuracy to Alpha Draconis, the celestial pole-star (the "imperishable star") of that time, and the south-facing one at a 44°5' angle was centered on the three stars of Orion's Belt. There is the "Queen's chamber," which is smaller and empty, and a seemingly unfinished empty chamber in the living rock

below ground. In addition to these chambers, there is an impressive 28-foot high passage known as the "Grand Gallery." It consists of carefully-fitted granite stones, some of which weigh 70 tons, and a high corbelled ceiling. It is cleverly engineered to minimize pressure on the low end of the chamber of the accumulated weight of its ceiling stones. All the chambers are connected by a number of steeply sloped ascending and descending passages.

The Great Pyramid was a geodetic marker, or fixed landmark, placed precisely between the two vertical boundaries of ancient Egypt. Just as the Space Shuttle embodies present-day understanding of physical principles such as strength of materials and complex mathematical relationships, the Great Pyramid, which does also, goes further. It was designed as an image of universal proportions, measures, and principles [Fig. 211. [29] Encoded within the geometry of the Great Pyramid are the value of pi, the principle of the golden section, the number of days in the tropical year, the relative diameters of the earth at the equator and the poles, and ratiometric distances of the planets from the sun, the approximate mean length of the earth's orbit around the sun, the 26,000-year cycle of the equinoxes, and the acceleration of gravity. Finally, and more importantly, the "Slope of the Horizon of Khufu,,, the Great Pyramid, was not a tomb for the dead king, but a place fora living man or woman to be initiated into the mysteries of life as `glorious light'.

The Science of Sound

Through more than 5,000 years of Egyptian civilization, music played a central role in their lifeways. Their numerous instruments - harps, lutes, flutes, sistrums, drums, and horns - depicted in paintings or carved in stone on monuments

[Fig. 22], moreover, attest to their knowledge of the science of sound. Their name for sound was "herw" (literally, voice). Furthermore, because music was thought to belong to things that were anterior to experience, this explains why they felt the human voice was the instrument "par excellence."[30]

The Egyptians were first to formalize the mathematical properties of music. They discovered the laws which refer pitch to the length and weight of the string material. Graphically illustrating this is the plumb bob. The plumb bob, the weight at the end of the plumb line called "tkh," by the Egyptians, expressed everything that oscillates or vibrates. To them, "tkh" also expressed the notion that every vibrating body emits a sound. Thus, the plumb bob was *very* often modeled in the form of a human heart. The heartbeat also provided them with a convenient measure of time; from its average rhythm they determined the length of the plumb line which would cause it to swing to that rhythm. They discovered the rate of oscillation of a pendulum (plumb bob) varies in inverse ratio to the square of its length, which in this case is 0.69 meters, or about 27 inches.

This mathematical relationship, which results from the phenomenon of classical gravitation, constitutes the essential basis of musical harmony, one of the direct applications of which is the length of a harp string. The longest string emits a sound of a certain pitch. Another string, half this one's length, emits a sound consisting of vibrations twice as rapid, and one octave higher. Thus all the intervals which define the seven notes of the diatonic scale represent the relationship between the stringlengths for any two notes which is the inverse of the relationship between their rates of vibration.

Music had a two-fold influence on man in ancient Egypt, one therapeutic, which was associated with the neter (god) Bes [Fig. 23] which dealt with the purely physical sensations and the emotions certain tone patterns amplified or reduced, and the other created or sustained by its trans-material effect associated with the god of psi, Heka (see section on psychoenergetics). In this regard, each note of music had a particular cosmic value.

The Egyptians compared the seven tones of the diatonic scale to the seven colors of the rainbow, and the seven moving stars (planets) - Mercury, Venus, Sun, Mars, Jupiter, Saturn, and the Moon [Fig. 24]. For example, the ratio between the lowest tone and the highest was the same as between Saturn (the most distant planet known to them) and the earth's moon (the closest celestial body to us). This certainly indicates that they had a modal system of music based primarily on the heptatonic and pentatonic system, thousands of years before the Greek Pythagorean system of modal music. Thus from the Egyptians' discoveries of the mathematical properties of music, they originated the sublime idea - which subsequently pervaded all antiquity, the middle ages via Kepler, and has even left traces in recent times - the idea of the harmony of the spheres.

Harmony to them was not restricted just to the earth, but was the ruling ethical principle (Maat) of Nature and the Cosmos. To the Egyptians, music (ordered energy) therefore was considered to be the force which regulates the organization of energy into matter coming out of Nun, the primordial infinite ocean of no-space/no-time, bringing into manifestation after the "first time," the entire life process [Fig. 3]. Thus the simple oscillation of the plumb bob, symbolizes their knowledge of the laws ruling the genesis of the universe, the heart, and the breath.

Psychoenergetics

The ancient Egyptians were known the world over as the masters of "magic" (psi): precognition, psychokinesis, remote viewing and other underdeveloped human capabilities.[31] Unfortunately, that legacy has been cloaked in controversy, marred with misunderstanding, and veiled in mystery. The problem begins with the multitude of meanings of the word "magic," many of which are often contradictory. Therefore, before discussing this subject, we first must know the extremely significant distinction between (non-science) "magic" and (science) psychoenergetics.

Psychoenergetics (also known in the scientific community as parapsychology and psychotronics) is the multidisciplinary study of the interface and interaction of human consciousness with energy and matter. Magic is the conscious attempt of an individual to `imitate' through ordinary sensorimotor means the operation of psychoenergetic (psi) phenomena. Thus, genuine psi phenomena such as precognition, psychokinesis, and remote viewing, in the distant past as well as the present, has always been closely associated with "magic," and the attempt to separate the two has only been a fairly recent activity. Psi, as a true scientific discipline, is being seriously investigated at prestigious universities all over the world (e.g., Princeton and Duke). We are concerned here only with psi in Egypt, not "magic."

Psi, known in Egyptian as "Heka" (who also was one of the divine principles [gods]), permeated all areas of ancient Egyptian life. Evidence for its existence and application is forthcoming from religious texts such as the "Book of the Coming Forth by Day" (The Book of the Dead), medical papyri such as the Ebers and Edwin Smith, folklore, funerary artifacts, temples and monuments, and even art, music, and jewelry.

Christian Jacq, in his book **Egyptian Magic,**[32] points out that **in Egypt, psi was an exact science.** It was a State-sponsored activity whose primary purpose was to preserve order (Maat) in the world and protect the Pharaoh. Psi was also used in the healing arts, mummification of the dead and in the construction of monuments. Their psi texts were not written by authors acting on whim, but were the work of official institutions such as the House of Life (university). Furthermore, contrary to the picture painted by popular occult literature and Hollywood movies, the process of applying one's psi talents was not the matter of simple chants (spells) or conjuring (though the voice and breathing rhythm were *very* important), nor was it subject to any improvisation - its efficacy depended on a precise sequence of actions, performed at specific times and undercontrolled environmental conditions, facilitated by the "hekau" (the Egyptian term for professional psi engineers), a very select group of priests, men and women, whose multidisciplinary training was, a long, arduous process. Today, in a similar manner, psi is researched and demonstrated in controlled laboratory and field experiments.

Egyptian Medicine

In discussions of the history of medicine, almost all books cite its earliest beginnings with the Greeks, Hippocrates and Galen. Rarely, if ever, do they mention that Hippocratic therapeutics had direct antecedents in Egyptian medicine. Professor Charles S. Finch at Atlanta University, Morehouse School of Medicine points out that: "Not only was the most important Greek healing deity, Asclepios, identified with the legendary Egyptian physician-architect, aphorist Imhotep, but the city-state of Athens used to import Egyptian physicians, as did most of the kingdoms of the Near East."[33]

Egyptian physicians, male and female, were instructed in the" per ankh," or House of Life, which served as a school, university, library, medical school, clinic, temple, and seminary. They were writing medical textbooks as early as 5,000 years ago. However, much of the training and instruction of the healing priests was transmitted orally as is done throughout Africa even today.

Ancient Egyptian diagnostic methods are strikingly similar to contemporary ones. A physician would begin with a careful appraisal of the patient's general appearance. This would be followed by a series of questions carefully designed to elicit specific responses describing the complaint. They noted physical conditions such as the color of the face and eyes, the quality of nasal secretions, the presence of perspiration, the stiffness of limbs or abdomen, and the condition of the skin. The physician was also at pains to notice the smell of the body, sweat, breath, and wounds. The urine and feces were checked, the pulse palpated and measured, and the abdomen, swellings, and wounds probed and palpated. The pulse-taking is very significant because it indicates that they knew of its circulatory and hemodynamic importance. Palpation of the abdomen and chest was performed along with certain functional tests we still use today, such as coughing for hernia detection and the extension-flexion maneuver of the legs for a dislocated lumbar vertebrae.

Out of perhaps hundreds of medical papyri, only ten are presently known such as the Ebers and Edwin Smith, yet these few give a vivid picture of the depth of Egyptian knowledge of anatomy and physiology. During the Old Kingdom (3000 B.C.E.) they had a good understanding of how the cardiovascular system functioned and the relationship between it and the respiratory system. They also knew the relationship between the nervous system and voluntary movements. They named and described all these systems, including the kidneys, uterus, bladder, and digestive tract.

Finch also points out that the Egyptians were well-versed in many pathological syndromes. They understood the origin of paralysis from spinal-cord injuries and recognized the traumatic origin of neurological symptoms such as deafness and urinary incontinence; they described many syndromes as being of cardiac origin. They also recognized the significance of heart palpations and arrhythmias and gave a rather precise definition of angina pectoris:

> "If you examine a man for illness in his cardia and he has pain in his arms, in his breast, and on one side of his cardia ... it is death threatening him."

The Egyptians diagnosed and treated trans-material disturbances. To the minds of the Egyptians, in fact, to most African people, all elements' of life, whether human beings, animals, plants, gods, and even inanimate matter such as stones and stars, are imbued with a trans-material primordial energy. The ancient Egyptians call this creative energy "za" (known as "prana" to the Hindus and "chi" to the Chinese), which human beings, under special conditions, could manipulate. The god Heka was also the personification of this energy. They understood man's vital essence, the spirit, to be contained in a net of energy: the body.[34] Thus, in the process of healing, the psi-physician/priest actually sought to restore the energetic integrity and harmony of the ill person. By the laying-on-of-hands, he or she could transfer their "za" which they received from the Pharaoh, who in turn received his "za" from the sun, to the patient.

This "magico-spiritual" aspect of African medicine still baffles Western-trained scholars and practitioners, and as such is dismissed, belittled, or downplayed. However, recent research is uncovering the "hard" evidence of the validity of this

aspect of African medicine: instruments which measure the extremely weak magnetic fields of the body have demonstrated the reality of that laying-on-of-hands healing modality. Furthermore, more than 30,000 physicians, nurses, psychologists, and other health practitioners world-wide have been taught a variant form of the ancient Egyptian laying-on-of-hands procedure called "therapeutic touch," developed by Doloris Krieger, M.D. and a professor at New York University School of Education, Health, Nursing, and Arts Professions.[35] Therapeutic Touch has been shown in controlled experiments, in hospitals and clinics, to enhance the body's immune system's functioning, lower blood pressure, and help the patient relax, thus reducing stress. Contemporary medicine is now beginning to discover what African people have always known, that treatment of man's trans-material nature was central to the healing process.

Experiments have also shown, for example, that our thoughts play a major role in our mental-physical health and behavior via nervous/immune-endocrine system interactions. Furthermore, it is generally accepted by contemporary medicine that close to 60 percent of all illnesses have trans-material origins. California biological psychiatrist Richard King's evaluation of the Egyptians' knowledge of the brain [Fig. 25], particularly the limbic system and the pineal gland, the "seat of the soul," indicates they diagnosed and treated trans-material illnesses. There is evidence that they knew how light effects the pineal gland. They also used sunlight-activated plant dyes for healing skin disorders such as psoriasis.

Imhotep, the world's first master multidisciplinarian - high priest, poet, astronomer, architect of the stepped pyramid of the Third Dynasty Pharaoh Zoser, and other

stone buildings at Saqquara, and royal physician - the "true" father of medicine -developed the first theory of heredity around 2850 B.C. He said a child acquires qualities of the parent through the semen of the father; this was the basis of the royal family's selective marriage policies. During the Greek period of Egyptian history, Hippocrates (the so-called father of medicine) further developed Imhotep's thesis.[36]

The Egyptians were one of the few people of antiquity to develop specialized medicine. For example, there was a separate guild of bone-setters who treated fractures and dislocations; of surgeons; doctors for the eye, teeth, belly, obstetric and gynecological problems, and the "hidden diseases" [Fig. 27]. From their more than 4,000 years of experience dissecting and bandaging mummies, their surgical technique benefited greatly. They had an array of knives and scalpels to excise tumors and drain abscesses. Majno states they even had the first disposable blades made from reeds.[37] They used red-hot metal instruments to seal off bleeding wounds. They had a large number of adhesives, mainly from gum and acacia trees and several types of resin. They were used to fasten linen bandages. They used molds from bread and cereals to treat wound infection; this indicates their knowledge of certain molds' bacterial properties. The embalmers were the specialists in using plants that had antibacterial properties; they found garlic, onions, and honey to be effective to varying degrees. After treatment of a serious wound, adhesive tapes would then be used to close the wound, just as they are used today.

Mummification

For the Egyptian, death as opposed to life, did not exist in his or her mind. Their language had no icon to express it. To them, it was nothing but a further step

in life or another dimension of life which their soul or "ba" could return from the Nether world to reanimate their body with "new light." From this perspective, the necessity for their secret art of making the "vestments of eternity" - mummification, can be better appreciated.

Mummification was a ritualistic process that required a team of skilled surgeons and chemical engineers, and took upwards of 70 days to complete, all under the supervision of one or more priests. Some of the steps involved were evisceration (the removed viscera were cleaned with a blend of palm wine, various spices, perfumes, stuffed with myrrh, aniseed and onions, and generally wrapped in bandages and then stored in canopic jars), evacuation of the brain, desiccation and washing the body inside and out with natron (a natural mineral salt common to the river Nile), anointing the now "purified" body with a special blend of aromatic oils and herbs, artistically wrapping it in seemingly endless bandages, each with a precise psychoenergetic value, soaked in resin, and finally enhancing it aesthetically by painting the protective divinities on it.

Embalming advanced considerably their anatomical knowledge, and the assignment of organic causes to disease, more than any other Near East culture contemporary to their own. Furthermore, the wrapping of mummies created a class of specialists in bandages, who more than likely, transferred their speciality into the field of surgery.

The Egyptians had a large "materia medica" using as many as 1,000 plant, animal, and mineral products in the treatments of illness. Night blindness, caused by Vitamin A deficiency, was treated with ox livers, a known source rich in Vitamin A. Patients

with scurvy caused by Vitamin C deficiency were fed onions, a known source of Vitamin C. They also had an effective pregnancy test! A sample of a woman's urine was sprinkled on growing barley grains; if they failed to grow, the woman was considered not pregnant, and if they did grow, she was declared pregnant. Modern experiments show this method to be effective in about 40 percent of tested cases. They knew the properties of mandrake roots and henbane, which decrease stomach activity, dilate the pupils, stimulate the heart and cause sedation, and used them in treatments. The Egyptians dispensed their prescriptions as pills, enemas, suppositories, infusions, and elixirs in accurate doses, causing one to wonder if they had separate pharmacies and pharmacists.

Painting - A Window to Ancient Egyptian Chemistry

Painting was in all cultures in the history of mankind an important tool to express symbolic, religious, and aesthetic impressions of a particular people. From 12,000 B.C. onto pre-dynastic Egypt, the pigments used in paintings found on rocks and cave walls world-wide were natural ones, generally made from plants. The development of synthetic pigments, in pre-dynastic Egypt (5500 B.C.) marks a significant development in the Egyptians knowledge of the properties of matter. It is not widely known that ancient synthetic color pigments store an enormous amount of information of both historic and scientific value such as the nature and potential source of raw materials, method of pigment manufacture, and development of chemical technology in the past and the links between different cultures over thousands of years.

One of the oldest synthetic color pigments in ancient Egyptian history is Egyptian Blue. H. Jaksch,[38] mineralogist at the Petrographisches Instit der Universitat Heidelberg, et al., did a systematic study of several hundred samples of Egyptian Blue from a huge number of temples and tombs from the Fifth Dynasty of the Old Kingdom (2480-2320 B.C.) till the Roman time (Caesar Tiberius, 14-37 A.D.). They discovered that Egyptian Blue was manufactured in a multistage process briefly described here. The ingredients: copper carbonate (malachite), silica (quartz sand), and limestone were mixed in the proportions according to the following equation:

$Cu_2CO_3(OH)_2$ +	$8SiO_2$ +	$2CaCO_3$	⟶	$2CaCuSi_4O_{10}$ +	$3CO_2$ +	H_20
Malachite	Silica	Limestone		Cuprorivaite	Carbon Dioxide	Water Vapor

The mixture was then heated to melting. The melting temperature was tightly controlled by the amount of plant ash flux or alkali salts added and did not exceed 742° C. The copper silicate melt was then rapidly cooled, thus producing a glass-bearing cake rich in cuprorivaite crystals. After cooling, the cake was ground and heated several times to accomplish a high degree of reaction and hence a good quality pigment. During the 18th Dynasty reign of Thutmosis III, bronze filings were added at the start of the mix leading to significant improvement in the overall quality of the pigment. This technological innovation was employed until Roman times. We can now see that it is no accident that the science "chemistry" originated in "Khemet" (Egypt). A check of the etymology of the word chemistry additionally support that conclusion: Khemet (Egyptian) ⟶ [al]chemy(Arabic) ⟶ Khemeiea (Greek) ⟶ chimista (Latin) ⟶ chemistry (English).

Egyptian Metallurgy and Electrical Engineering

A very significant step in the development of a civilization is the production of objects made of metal, for that makes possible the movement to more advanced forms of tools and machine technology.

A cursory examination of the Egyptians' jewelry indicates that they had an advanced knowledge of minerals, the separation of the precious ores from the rock plus their subsequent purification, and understood their physical characteristics. They made different types of metal alloys such as bronze (copper with 3%-10% tin) and were adept at metal fabrication and casting, making tools, jewelry, statues, wire, rivets, and surgical and musical instruments from gold, copper, bronze, silver, tine, and lead.[39]

Egyptian iron antiquities were rare until around 1500-1200 B.C. when evidence appeared that they were smelting and welding iron and steel. During the Old Kingdom, an iron chisel was found inside a pyramid, thus giving strong support that iron tools were used as early as 2600 B.C. to cut and finish artworks of granite in addition to copper. [40] They also used meteoric iron and magnetite to make special instruments for their esoteric "Opening of the Mouth" ceremony, an event designed to expand the psychoenergetic aspects of a living person's and even a deceased's consciousness. The Egyptians call the natural magnet "baa-n-pet" (celestial metal), or sometimes the "bone-of-Heru" ([Greek] Horus). Being associated with their god Heru, magnets were thus very sacred stones; moreover, they ascribed the power contained in it as the "central fire of the universe-wheel." This is seemingly analogous to contemporary astrophysicists' description of the extremely energetically intense radiation source in our galaxy's center.

Electroplated gold and silver objects have been found in Egypt from roughly the Middle Kingdom (2100 B.C.) to the Greek era of the Ptolemies (350 B.C.). Nineteenthcentury French archaeologist Auguste Mariette in the **Grand Dictionaire Universel du 10th Siecle** describes such artifacts he found excavating an area near the Sphinx. Wooden flagstaffs about 30 meters tall, placed in front of Egyptian temples from the Middle Kingdom onward, had the top end capped with a sheath of gold-plated copper. They were described in a Ptolemic inscription of about 320 B.C. as intended to "cut the lightning out of the sky." Thus the flagstaffs could have acted as a type of antenna. But how, where did the source of electrical energy to plate one metal onto another come from?

Well, perhaps it was their study of electric eels in the Nile River along with their understanding of the basic principles of chemistry that inspired their development of clay-pot electro-chemical storage batteries [Fig. 27], which probably was that source of electrical energy. A number of these proto-electric cells (dated to around 250 B.C.) were serendipitously found in 1962 in Bagdad, Iraq by archaeologist Wilhelm Konig, director of Iraq Museum Laboratory.

The typical Iraqi clay-pot battery is 6 inches high, 1.5 inches in diameter, with a 5 inch long cylindrical sheet copper core. The edges of the cylinder and the copper plate bottom were soft-soldered with a 60/40 lead-tin alloy, which is comparable to the solder in use today. (The Egyptians also knew the technique of hard colloidal soldering, in which the parts to be joined are stuck in place with a gum mixed with copper-sulfate, obtained from powerful malachite.) Inside the copper tube's center was an iron or bronze rod and surrounding it was a 5% electrolyte solution of either

copper sulfate, vinegar, acetic acid or citric acid. The ends of the copper tube were sealed with bitumen or asphalt.

As many as ten of these batteries, Konig concluded, were hooked up in a series in order to increase the output. A reconstruction of the Iraqi battery by Willard Gray of the General Electric High Voltage Laboratory in Pittsfield, Massachusetts produced 0.5 - 2.0 volts.[41] Thus at least 1,500 years before Galvani did his frog leg experiments, the Egyptians and Mesopotamians not only had a proto-theoretical conception of electrical properties of matter, and even the air - they also applied their knowledge based on their societies' needs.

Egyptian Aeronautics

One of the more extraordinary artifacts of ancient Egypt was the discovery in 1898, in a tomb near Saqqara, of a model glider or sailplane [Fig. 28] made of sycamore wood dating from about third or fourth century B.C. It lay undisturbed, buried in a box of "bird objects" in room 22 of the Cairo Museum's basement until 1969, when museum archaeologist, Dr. Khalil Messiha and his flight engineer brother, Guirguis, redis-covered it. A special research committee was established by the Egyptian Under Secretary of the Ministry of Culture, M.G. Moukhtar, in December of 1971 to investigate it. From their examination of it and bird models in the museum, the committee concluded that this object definitely was not a bird - but a model glider.[42]

This ancient Egyptian model glider looks contemporary and bears a strong resemblance to the American Hercules transport aircraft which has a distinctive

reverse dihedral wing. The saqqara model glider's body (14 cm long) has an aerofoil shape, which lessens drag, and the wing section (18 cm wing span) shows that its wing surface is part of an ellipse, which gives it good stability in flight. The tail is the most interesting part of it, because no bird has a vertical fin. Another feature that aerodynamic experts discovered was that all of its highly accurate integral proportions were present in ratios of 2:1 or 3:1. Clearly the African, Pa-di-men, who made it studied bird flight very carefully.

While the Massiha brothers noted that this object did make an excellent glider and could soar through the air for a considerable distance with only a slight hand thrust, it definitely was not a toy. It was a scale model of a full-size glider! The Egyptians usually first made scale models of things, such as ships, temples and obelisks before making full size versions. They speculated that it would have only taken a small catapult to get a full-size glider into the air. The Guinness Book of World Records, under the generic heading "Gliders," mentions Isadore William Dietches, a British businessman, who has researched evidence of the use of gliders in Ancient Egypt from 2500 B.C. - 1500 B.C. He says the Egyptians used their early planes for travel, expeditions, and recreation! To date more than 14 additional objects have been discovered in other tombs and identified as model airplanes.

Dr. Jack Low,[43] a research engineer who has worked for the British Ministry of Aviation, resource manager of British Airways Concorde fleet, and Concorde pilot, says: "If the Egyptians could build pyramids and dam the Nile, it's not too difficult to imagine them having the ingenuity to make gliders out of papyrus and glue. They certainly were the most advanced engineers of their day, and flying had to start

somewhere." Berthold Laufter,[44] in a publication of Chicago's Field Museum of Natural History, "The Prehistory of Aviation," reminds us that "our modern progress in aviation is not solely due to the efforts of the present generation, stupendous and admirable as they may be, but presents the process of a gradual evolution of ideas which have grown out of the imagination, endeavors, experiments, triumphs, and failures of many past ages."

Conclusions of Nile Valley Section

The level of scientific development attained in ancient Egypt was unmatched by any of their contemporary nations. They traveled to other nations and shared their knowledge (Fig. 29). To them, we owe the concepts of most of the fundamental physical quantities: area, volume, weight, distance, density, and time, along with standard units and accurate methods of measurements using these quantities. Regarding technology for example, today's small metal locks and keys owe their basic design to large wooden locks and keys invented 4,000 years ago in Egypt as well as folding beds and chairs. In regard to medicine, they produced the first physicians, the first extensive medical literature and knowledge; the Western medical tradition is an extension of the Egyptian one, and not the Greek. In fact, the Greeks called Egypt the seat of scientific knowledge and sent many of its most brilliant scholars there to study such as Thales, Democritus, and Pythagoras. Perhaps it was this reason Alexander made Alexandria, Egypt, the capital of his empire after he conquered Egypt in 325 B.C.

Frequently, it is assumed that, during the Hellenistic period of Greek rule, the African

character of Egypt was negligible; however, to the contrary, the Greeks practiced a policy of assimilation, marrying Egyptian women and even adopting Egyptian religion. During the Greek rule of Egypt, the first steam engine was built by Heron in Alexandria around 100 C.E. The famous steel for the superb swords of Damascus was made in only three locations; one was Egypt. With the burning of the great library at Alexandria and the plundering of Egyptian antiquities over the centuries, much has been lost of the history of Egyptian science, and few names of their great scholars survive. Nevertheless, the scope of their scientific knowledge concerning the human body and mind, the earth and the origins of the universe, and precision of their architecture - the pyramids, the Temple of Amen-Ra at Karnak, not only challenge the abilities of today's scientists and engineers, but also anticipate the many discoveries of the Twentieth Century.

AFRICAN SCIENCE AND THE ISLAMIC TRADITION

Following the collapse of the Roman Empire, Europe was in a cultural and scientific decline. However, throughout much of northern Africa, the Middle East and Iberian Spain, from the Ninth to the Thirteenth centuries, the light of Islam was spreading. New centers of learning were established: Cairo, Egypt; Granada, Seville, Cordoba, in Moorish (African-ruled) Spain; and Carthage, Tunisia. African Islamic scholars founded the first universities in these locations.

No understanding of science as learned under the influence of Islam is possible without a comprehension of Islam itself. Seyyed H. Nasr points out in his book, **Islamic Science: An Illustrated Study,** that Islam is most of all concerned with what man is, or rather with how man can become what he really is in

his profoundest and primordial nature - a theomorphic (god-like) being created to reflect the Divine in all its majesty and beauty.[45] Islamic holy books, such as the **Holy Quran,** create an atmosphere for the cultivation of the sciences by emphasizing the virtue of pursuing all knowledge which confirms Divine Unity. An essential feature of the teachings of Islam, as reflected in its sciences as well as its philosophy and cosmology, is that equilibrium is not possible unless there is harmony with the total cosmic order - macro, micro and ultimately the Metacosmic Reality. Through Islam we see a new expression of the ancient Egyptian metaphysical, philosophical and ethical paradigm Maat.

THE HOUSE OF WISDOM - EGYPT'S PREMIER SCIENCE ACADEMY

The House of Wisdom, Dar el-Hikma, was built in Cairo, Egypt, in 1005 C.E. with a grant by the Fatimid caliphs, who were great patrons of science and were then the rulers of most of Northern Africa. Many significant contributions to world knowledge came from this science academy, continuing an unbroken tradition of 4,000 years of scientific contributions by Egypt.

During this period in the 11th century, one of the greatest Islamic scientists, a physicist, mathematician, astronomer, and physician, Abu Ali al-Hasan ibn al-Haytham, known in Europe as Alhazen, who worked in the Cairo Academy, gave the first comprehensive treatise on optics. He explained refraction, reflection, the focusing of light with lenses, the pinhole light effect, spherical aberration, and binocular vision. He built spherical and parabolic mirrors. His works were seriously

studied 500 years after his death by Roger Bacon, Johannes Kepler, and practically all students of science in Europe of that time. This was due, in large part, to the translation of Egyptian, Hindu and Arabic works into Latin by an African merchant called Constantine.

The outstanding African scholars of this period were of different religions, yet they shared a common spirit of scientific inquiry and language. Arabic was the dominant language of scholarship at that time just as English is today, and although those scholars were steeped in Islamic cultural lifeways, the African-Christian and African-Jewish scholars of the day maintained the integrity of their own religious traditions.

In their excellent article on the Cairo Science Academy, Professors Beatrice Lumpkin and Siham Zitzler point out several African-Jewish scholars of that time. Mashallah was an Egyptian-Jewish astronomer who, with his Persian colleague made the measurements for the plan of the new city of Bagdad. Isaac Judaeus (Abu Ya'quab ibn Qarish Sulaiman el-Isra'ili), also an Egyptian-Jew, was the physician to the Caliph in Tunis. Among his medical writings are descriptions of fevers, lists of medicinal drugs and treatises on nutrition, urine and ethics. Perhaps the most widely known African-Jewish scientist, philosopher, physician, and master teacher of that time who practiced in Moorish Spain was Moses ben Maimon, also known as Maimonides.[46]

The rapid progress of technology in this period also stimulated the development of science. Windmills were invented at this time and were first described in 947 by Al-Mas'udi, an Arab writer who lived in Egypt. **The Book of Ingenious Devices,** published in the ninth century by the brothers Banu Musa bin Shakir, show the high

level of Muslim technology. The Banu Musa employed self-operating valves, timing mechanisms and delays, hydraulically operated worm and pinion gears, and automatically operated cranks.

Today the science contributions of the Islamic-African science tradition are relatively unknown in the Western world because of the lack of humility of many Medieval European scholars who diligently imitated, copied and plagiarized the works of many Islamic scientists. A Turkish science historian, Fuat Sezgin, reports in a multi-volume book that their vanity was so pervasive that i n the 12th century a decree was issued in Seville, Spain, forbidding the sale of scientific writings to Christians because they would translate them and then publish them under their own names. Table one lists a few examples of the discoveries that have been inappropriately claimed:

TABLE 1

NAME OF DISCOVERY	ISLAMIC DISCOVERER	EUROPEAN DISCOVERER
Refraction of light	Ibn al-Haytham	Newton
Law of gravity	Al-Khazin	Newton
Air and its weight	Al-Khazin	Toricelli
Principles of astronomy	Al-Battani	Copernicus
Principles of Astronomy	AI-Biruni	Galileo
Scientific method	AI-Biruni	Bacon[47]

Mali was one of the three great empires of West Africa. It succeeded Ghana and was in turn succeeded by Songhay. These three Empires were centers of trade and learning from 900-1594. C.E. Mali inherited the ancient knowledge of Ghana. Historian Chancellor Williams points out in his book, **Destruction of Black Civilization,** that Ghana's known history goes back to beyond the 25th Dynasty when the last of the Black Pharaohs ruled Egypt. Egypt and Ethiopia were Ghana's major trading partners. [48]

Mali became well-known as it rose to prominence in the medieval world, following Sundiata's conquest of Ghana, but its known history goes back to paleolithic times. Distinguished African and Islamic scholars came to teach and study at the University of Sankore in Timbuktu. The Moorish poet, architect and astronomer Es-Saheli (from Granada, Spain), was one of the most widely known.

During the Songhay Empire under Askia Mohammed, there were universities and learning centers established in the cities of Gao and Jenne in Mali. Professor of History, John Jackson points out in his book, **Introduction to African Civilizations,** that in these schools, colleges and universities of the Songhay Empire, courses were given in astronomy, mathematics, ethnography, medicine, hygiene, philosophy, logic, diction, rhetoric, and music. At Jenne there was a medical school that trained physicians and surgeons of great skill. Among the difficult operations performed successfully by doctors at Jenne was the removal of cataracts from the human eye.[49]

ASTRONOMICAL KNOWLEDGE OF MALI'S DOGON PEOPLE

Inheritors of the scientific tradition of the Mali and Songhay Empires, the Dogon people are keepers of astronomical knowledge so astounding that some Western scholars such as Kenneth Brecher of the Massachusetts Institute of Technology arrogantly exclaim, "They have no business knowing any of this." The astronomer-priests of the Dogon had for centuries, it seems, a very contemporary understanding of the heavens.[50]

They knew of the rings of Saturn, and the moons of Jupiter, the spiral structure of the Milky Way Galaxy, where our star system lies. They claimed that billions of stars spiral in space like the circulation of blood in the human body. They knew the moon was a barren world. They said it was "dry and dead," like dried blood.

Perhaps the most remarkable facet of their knowledge is their knowing intricate details of the Sirius star system, which presently can only be detected with powerful telescopes. The Dogon knew of the white dwarf companion star of Sirius, the brightest star in the sky. They knew its approximate mass ("It is composed of `sagala,' an extremely heavy, dense metal such that all the earthly beings combined cannot lift it"), its orbital period (50 years) and its axial rotation period (one year). Furthermore, they knew of a third star that orbits Sirius and its planet. The X-ray telescope aboard the Einstein Orbiting Observatory recently confirmed the existence of the third star. The Dogon, with no apparent instrument at their disposal, appear to have known these amazing facts for at least 500 years!

AFRICAN STEEL-MAKING, SHIP-BUILDING AND MEDICINE

Though we focused a great deal of attention on Egypt's contributions, similar achievements in medicine, agriculture, astronomy, architecture, engineering, metallurgy and psychology are found all over the continent of Africa. Carbon steel was being made in blast furnaces producing temperatures up to 1800° C in Tanzania 2,000 years ago. The "Temple" of Great Zimbabwe was one of the largest stone building complexes in Africa. Ships were built that could carry up to 80 tons. Chinese records indicate Africans shipped elephants there from a port in Mombassa, Kenya, in the 13th century.

Christian missionary records mention complex medical operations, such as Caesarean sections, being performed using antiseptics in East Africa, years before Lister made it a common practice in the Western world. Plant medical preparations were used extensively for maladies such as skin infections, abortion, fever, rheumatism, neurotoxic venoms, intestinal parasites, tumors, convulsions, venereal disease, psychosis, and bronchitis - all of which are as effective as those in use in Western medicine.[51] It should be noted that a number of universities are carrying out projects to catalog and identify upwards of 5,000 African plant medicines which could be useful in treating health problems all over the world.

CONTEMPORARY AFRICAN SCIENCE

Africa, we now clearly see, has greatly contributed to science and technology. Yet for the past several hundred years, science and technological advances in Africa, until

recently, have come virtually to a halt. This is because of a number of reasons: 1) a general continent-wide lack of interest in science, 2) outside interference by its former European colonial plunderers and more recently by well-meaning international agencies, 3) either a misguided or no governmental science policy, 4) ethnic conflicts, 5) the inappropriate or irrelevant application of African students' Western science and engineering training, uncritical adoption of Western scientific methodologies to deal with the contingencies of African needs, which leads to off-base research goals, and 6) the brain drain of more than 3,000 technically trained Africans staying in the West and in the Eastern-Block countries, namely Cuba and Russia. Yet in the face of all these obstacles, a growing number of African scientists have been starting new scientific and technical organizations and societies or redirecting existing ones with the vision of adding new chapters to the legacy of their ancestors.

Today there are several hundred of these organizations[52,53] with thousands of members which represent a vast intellectual resource that is gradually being tapped. They publish journals of their affairs and hold conferences and workshops. Some of them include the Nigerian Academy of Science, the International Centre for Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya, and the Association Scientifique de Cote d'Ivoire (ASCI) in the Ivory Coast. In Ghana there is the University of Science and Technology (UST).[54]

Dr. Dwuma-Badu, director of UST's pharmaceutical chemical department, is working on developing herbal medicines. Others at UST's chemical and biological departments are researching possible bacteria to leach gold ore from the sulfur compound in which it is embedded. At the University of North Carolina, Ghanaian,

Nickolas Darkwa is researching the prospects of making paper from the stalks of plantain, a banana-like plant that is very common in West Africa and the Carribean. His work and others is hoped to lead to the development of a Ghanaian paper industry. J. Maud Kordylas, head of Ghana's Food Research Institute is working on developing improved strains of the winged bean for use as a weaning food. She is one of the extremely rare educated African women with a science background. Regarding higher education in general, African women are severely sexually discriminated against such that there are unwritten quotas limiting their enrollment in colleges locally and internationally.

One of the oldest African scientific organizations is the Institut Founamental d'Afrique Noire (IFAN) at the University of Dakar, Senegal. At IFAN, many areas of science are being investigated as in Ghana. Director of IFAN's Radio Carbon Laboratory was the late world-renowned physicist, linguist, historian, Egyptologist, philosopher, writer, teacher, and politcal activist, Cheikh Anta Diop.

Diop was born in 1924. From his early years, he dedicated his entire life to the single-minded pursuit of one objective - the rebirth and revitalization of the Black world in the domains of culture and leadership. Such a great undertaking, he knew, called for deep knowledge and understanding in multiple disciplines. And to meet that challenge from 1946 to 1960, as a student in France, he worked for and obtained degrees in the many different areas previously mentioned.[55]

His relentless pursuit for truth frequently got him into trouble with the Senegalese government and his peers. At the 1974 United Nations Educational Scientific and

Cultural Organization (UNESCO) symposium called the "Peopling of Ancient Egypt", called to settle the question who were the ancient Egyptians, a very heated discussion ensued following his presentation of evidence from two different disciplines, destroying the myth of the European origin of those Africans as currently depicted in almost all Western history books and Hollywood movies. Diop presented "hard" scientific evidence to support his case. First he gave an analysis of the melanin (skin pigment) content from a mummy. His results indicated that ancient Egyptian people were from Central Equatorial African ethnic groups, the Twa and the Anu, and from Northeastern African ethnic groups, the Nubians and Tubbon, Second, he presented linguistic evidence showing very strong affinities between many currently spoken and written African languages and the language of the ancient Egyptians, and third, he presented descriptions of the ancient Egyptians as reported by many classical Greek writers.[56]

In the spirit of Diop's scholarship and commitment, 26 science fellows from countries all over Africa founded the African Academy of Science (AAS) in December of 1985.[57] The AAS has a program to develop projects on the topics ranging from drug-resistance in malaria to the research training and the repair, maintenance and local manufacture of scientific equipment. The AAS springs from Nobel prize winning Pakistanian physicist, Abdul Salaam's Third World Academy of Science (TWAS). Professor Thomas Odhiambo, a Kenyan entomologist is the academy's first president. The academy will offer fellowships and prizes, as well as coordinating research programs. By its very existence the AAS hopes to raise the consciousness of African people, particularly civil servants, of the importance of science.

SUMMARY: SCIENCE IN AFRICA

Emerging from all the above is an outline of African peoples' role and contributions to science, technology and engineering. We examined man's earliest beginnings in the heart of Africa - how he discovered time and fire, domesticated animals, developed writing, agriculture and calendars. We learned how he developed religion and why he intensely studied the stars. We then focused our attention on some of the many achievements of the ancient Egyptians. We discussed their scientific paradigms and their impact in the Nile River Valley area, as well as on other Northeastern African people for centuries. We took note of their astronomy and the legacy they left: The 24-hour day, equal hours of the day and the 365-day year. We talked about their achievements in medicine, metallurgy and aeronautics.

We then turned our attention to the Islamic tradition's scientific achievements in Africa. The work of the foremost members of the "House of Wisdom," the Cairo Science Academy, were examined. The work of some African-Jewish scholars of the Cairo Academy and of Moorish (African) Spain was discussed. The scientific tradition of Mali's legendary city Timbuktu and the extraordinary astronomical knowledge of Mali's Dogon people were highlighted. We made a cursory survey of African steel-making, ship-building and medicine. Finally, we highlighted the work being done today in African Science Institutions. Yet, despite all of this, we have not even scratched the surface of Africa's gifts to world knowledge.

PART II - AFRICAN-AMERICAN CONTRIBUTIONS TO SCIENCE AND TECHNOLOGY

INTRODUCTION

When African people were brought as captives to the "new world," they did not come as uncivilized, primitive people, but with a rich cultural heritage and accomplishments in all human endeavors spanning hundreds of thousands of years. Some of the accomplishments in science and technology were outlined in the preceding sections. It is within this larger historical framework that African-Americans' contributions in the areas of science and technology must be examined. For even under the oppressive and debasive American social order of slavery, Black people's spirit of scientific inquiry and ingenuity was not lost, just translated to deal with a uniquely different set of conditions. Foremost in the hearts and minds of the African captives were ways to make living less intolerable and the eternal desire for freedom. Yet even while engaged in those urgent efforts, Black people managed to make contributions to science and technology in America so significant that their impact is still felt today, though much is still unknown.

AFRICAN-AMERICANS PLAY KEY ROLE IN DEVELOPMENT OF AMERICAN MEDICINE

Among the assets that the African slave brought with him to America were proven methods of relieving pain and treating diseases. As previously mentioned, the treatment and prevention of disease using plant medicines were widely practiced on the African Continent for thousands of years prior to the "discovery" of America.

When Africans found themselves in the unsettling conditions of slavery, it was only natural that they would search the plant kingdom here for remedies for the ailments and diseases they acquired here. Many slaves gained such wide reputations for their healing powers in the slave community that they attracted the attention of whites.

Robert Hayden and Jacqueline Harris, in their book, **Nine Black American Doctors,** state that slaves in early New England often served as apprentices to their owners who were doctors. Primus, a slave from Connecticut, helped his owner in surgery and in the general practice of medicine. When the doctor died, Primus took over his owner's practice. He was so successful throughout the county that even his former owner's white patients did not object to being treated by him.. Papin, a Virginia slave, developed extremely effective treatments for skin and venereal disease. His work was so outstanding that in 1729 the Virginia Legislature bought him from his owner, thus freeing him from slavery, to practice medicine exclusively. In 1733 another Virginia slave was freed by the state and given a pension for life following his discovery of cures for scurvy and distemper. In 1772, a slave named Ceasar had gained such a reputation for his use of roots and herbs to cure poisoning, and even rattlesnake bites, that the State of North Carolina purchased his freedom and gave him a pension of $500 a year for life.[58]

Many treatments, such as vaccination used by the slaves for diseases during the colonical period, are still used today. The concept of vaccination as a method to prevent people from acquiring smallpox was the contribution of a slave named Onesimus from Boston. In 1721, Onesimus described to his owner, Mather, the process of innoculation for the treatment of small pox he received in Africa.

Enthusiastically, Mather contacted ten other doctors in Boston and told them about the African practice of deliberately infecting healthy persons with smallpox as a way to make the body immune to a severe attack of smallpox. One of them, Dr. Boylston, after successfully treating his own son and two of his slaves, innoculated 241 people and only six of that group caught smallpox. Today, smallpox vaccination has virtually eradicated the disease worldwide.

One of the most prominent doctors of the 19th century was Martin R. Delany, a free Black man from Charleston, West Virginia. He began to practice medicine as a 19-year-old apprentice in Pittsburg, Pennsylvania. He went to Harvard Medical School and after leaving there around 1853, when not practicing medicine, he traveled to Africa, Europe and throughout America, using his knowledge of medicine, history, and religion to defend the intelligence and ability of African-Americans. Recognizing his worth to his community, the City of Pittsburg appointed him to a city medical board that counseled poor Black and white people.

In May 1891, a young Chicago Black doctor, Daniel Hale Williams, opened the Provident Hospital and Training School Association, the first institution of its kind to serve the Black community. This came about as a result of his sincere commitment to the progress of Black people in every phase of medical care, from the delivery of medical services to eliminating racism in hospitals and nursing schools. Two years after he opened Provident, Dr. Williams was on duty when James Cornish, a victim of a street fight, staggered into the emergency room with a knife stuck in his chest. Later during the night, after receiving treatment, his condition began to deteriorate. Dr. Williams decided to perform a never before attempted open-heart surgery to save the man's life. The operation was a success

and Cornish lived 20 more years. Provident Hospital today is one of the premier health care institutions in Chicago, Illinois.

Solomon Carter Fuller's grandfather was a former slave who had purchased his freedom and emigrated to Monrovia, Liberia, in Africa. Fuller left his homeland in 1889 to further his education at Livingston College, a Black school in Salisbury, North Carolina. He was a pioneer in neuropsychiatry. He is internationally known for his work on different forms of mental illness and a rare brain disease known as Alzheimer's Disease. His work centered on physical disease and changes in the body, which are factors in many mental disorders. His unique background of being exposed to both traditional medicine while in Africa and the Western medical tradition gave him new insights in the treatment of mental disorders. In his lab at Boston University, he was one of the first physicians to use photomicrographs of brain tissue to study cellular structure changes. He pioneered the study of life-stress effects on the mental health of his patients and used psycho-therapy to help them. As a result-of his work, in 1909 he was invited to share his knowledge at a landmark meeting at Clark College in Worchester, Massachusetts, with the world's three leading psychiatrists, Sigmund Freud, Carl Jung and Alfred Adler.

These few sketches of African-Americans in medicine only begin to tell the story. There are so many more, like William A. Hinton, who devoted his life to the fighting of syphilis; dermatologist Theodore Lawless; Jane C. Wright, who pioneered the use of chemotherapy to treat cancer; and Richard King, a biological psychiatrist, who is doing landmark work on neuromelanin and psychosis.

PATENTS, INVENTIONS, AND CONTRIBUTIONS

Black peoples' accomplishments evolved from needs of American society at a given time. Historian Robert Hayden, in an excellent article in the book, **Blacks in Science Ancient and Modern,** says that during the 18th century there was a considerable need for skilled craftsmen to do painting, house construction, ship-building, brick-making, iron-working and also silver and goldsmithing.[59] Black craftsmen skilled in those crafts in Africa found an outlet for their trade, producing artifacts for colonial America. These craftsmen often made the tools and the support equipment for their various crafts. Broadus Butler, in this book, **Craftsmanship:** A **Tradition in Black America,** states, "It is important to know that at the time of the 1860 census there were already 488,000 free Africans in addition to 3 million slaves in the South and another 1,000,000 Africans in the North whose skills were generally being used.[60]

Prior to the end of the Civil War, few "official" records mention inventions by African slaves. None of the inventions made by slaves could be patented by the United States Patent Office. In 1858, Attorney General Jeremiah S. Black had ruled that since a patent was a contract between the government and the inventor, and since a slave was not a citizen of the United States, he could neither make a contract with the government nor assign his invention to his master. Thus, it is impossible to document the existence of contributions by slaves whose creative skills made their lives less a burden and were catalysts to America's rapid industrial growth. Jo Anderson, a slave on the plantation of Cyrus McCormick, is said to have made a significant contribution to McCormick's grain harvester. Yet he is only credited in "official records" as being a handyman or helper to McCormick.

The national ban on patents for slaves did not apply to those made by "Free Persons of Color." The first known African-American to receive a patent was Henry Blair in 1834 for a seed planter, and in 1836 for a corn harvester. Official records described him as a "Colored Man." In the years following the Civil War to 1913, the newly freed Africans sought increased opportunities in many industries in the North. However, they were excluded from the organized work force, especially if they were highly skilled, hence highly competitive. Nevertheless, an estimated 1,000 inventions by African-Americans had been patented in the fields critical to America's industrial development: agriculture, industrial machinery, and safety, electrical, and communication equipment.[61] Some of them are listed in Table Two.

Appendix B shows some of the original patent drawings used by inventors and also copies of the original patents filed with the US Patent Office.

TABLE 2

INVENTOR	INVENTION	PATENT NO	DATE
Norbert Rillieux	Improvement in sugar making	4,8798	10 Dec 1846
L. S. Burridge	Typewriting machine	315,386	7 Apr 1895
A. Miles	Elevator	371,207	11 Oct 1887
C. B. Brooks	Street sweeper	556,771	17 Mar 1896
J. L. Love	Pencil sharpener	594,114	23 Nov 1897
R. P. Scott	Corn silker	524,223	7 Aug 1894
Fred M. Jones	Removable refrigeration	2,475,841	12 Jul 1949
J. H. Smith	Lawn sprinkler	581,785	4 May 1897
L. C. Bailery	Folding bed	629,286	18 Jul 1899
W. Johnson	Egg beater	292,821	5 Feb 1884
J. H. Evans	Convertible settee & bed	591,095	5 Oct 1897
J. T. White	Lemon squeezer	572,849	8 Dec 1892
A. L. Lewis	Window cleaner	483,359	27 Sep 1892
Granville T. Woods	Telephone system & apparatus; Apparatus for transmission of messages by electricity; Steam boiler furnace	371,241 315,368 299,894	11 Oct 1887 7 Apr 1885 3 Jun 1884
W. B. Purvis	Fountain pen	419,065	7 Jan 1890
John F. Pickering	Air-Ship	643,975	20 Feb 1900
J. H. Sweetning	Device for rolling cigarettes	594,501	30 Nov 1897
J. A. Burr	Lawn mower	624,749	9 May 1899
Lewis H. Latimer	Electric lamp	247,097	13 Sep 1881
W. H. Richardson	Childs carriage	405,599	18 Jun 1889
J. E. Matzeliger	Shoe lasting machine	129,843	2 Jul 1872
Issac Johnson	Bicycle frame	634,823	10 Oct 1914
Garrett Morgan	Automatic stop signal; Gas mask	1,475,024	23 Nov 1923
T. J. Marshall	Fire extinguisher	125,063	26 May 1872
R. F. Flemmings, Jr.	Guitar	338,727	30 Mar 1888
Sarah Boone	Ironing board	473,653	26 Apr 1892
John Stanard	Refrigerator	455,891	14 Jul 1891

The irony of African-Americans obtaining patents for their various devices is that they are never mentioned in the inventions' historical contexts. Furthermore, they rarely reap even a fraction of the money the invention made.

Appendix B shows some of the original patent drawings used by the inventors and also copies of the original patents filed with the United States Patent Office. In African societies, science and technology, religion and art, and music and politics are not separate and distinct pursuits, but constitute a unified process. The scientist has 8 strong moral and ethical foundation from which he conducts his activities, such as the Egyptian principal, Maat. There (s always some practical reason for their research-it must benefit their people. As tie examine the following short profiles of a few of tens of thousands African-American contributors [62,63,64] to scientific knowledge, we discover that they are inheritors and keepers of the same tradition.

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- **Benjamin Banneker** (1731-1806) - Self-taught astronomer, mathematician, musician, and surveyor. He made America's first clock. He published an almanac for ten years, beginning in 1792. It contained a wealth of information, such as accurate dates for astronomical phenomena--solar and lunar eclipses and moon phases, sunsets and sunrises, weather forecasts, information on history, literature, farming, anti-slavery commentaries and religion. It should be pointed out that Banneker, unlike Benjamin Franklin, did all the calculations himself. Secretary of State and slave owner Thomas Jefferson appointed Banneker to survey the site for the capital, Washington, [}.C.' shortly after reading a copy of his almanac. He also wrote a proposal for the establishment of a United States Department of Peace. Today, nearly 200 years later, a bill is in the congress to do just that.

- **George Washington** Carver (1860-1943) -Agricultural scientist. It was Carver, born of Wave parents, who revolutionized and revitalized the dying agriculture of the South. Because of his efforts, the peanut crop alone brought the South an income of $60,000,000 in a single year! He taught agriculture and bacterial

botany and did research in plant pathology, problems with soil, moisture, sunlight and plant reproduction at Iowa State. In 1896, Booker T. Washington asked Carver to be the first Director of the first Black science and industrial institute, Tuskegee Normal and Industrial Institute.

With meagerly equipped laboratory facilities and a barren, unbelievably poor 20-acre patch of land assigned to him, Carver and his students performed miracles. First, to revitalize the soil, they planted legumes, such as peanuts, clover and peas. This was because legumes have nitrogen-fixing bacteria on their roots that extract nitrogen from the air and chemically convert it into nitrate compounds. Those nitrates are then used by the soil as fertilizer, thus enriching it. He then planted sweet potatoes and then cotton, thus introducing to farmers the concept of "crop rotation". As farmers all over the South began following Carver's method, the results were far beyond their expectations-warehouses were overflowing with peanuts that could not be sold and had begun to rot.

To solve this overabundance problem, Carver went back to his lab and in a week introduced the concept of "waste recovery". From his research he made 325 different products from peanuts, such as milk, cheese, instant coffee, face powder, printing ink, shampoo, vinegar, dyes, soap, and wood stains. He then turned his attention to the sweet potato, discovering 118 different products that could be made from it, such as flour, tapioca, starch, ink, dyes, mucilage, and synthetic rubber. From the pecan he extracted 75 different products, as well as hundreds of products from waste material, such as cornstalks. He even found additional uses for cotton, and from soy beans he developed plastics.

Soon many industries developed that made use of these products, and Carver received numerous awards and offers to join these and other companies. Thomas A. Edison invited him to join his staff at Orange Grove, New Jersey, with unlimited laboratory facilities and a $100,000 per year salary; Henry Ford made a similar offer. He turned all offers down, for Tuskegee and his people needed him more. Furthermore, as a deeply religious man, he felt his work was God's work and it was priceless.

- **Lewis Howard Latimer** (1848-1927) - Research scientist, inventor, musician, poet, artist, writer and draftsman. Latimer, son of a freedom-seeking slave, became one of the few men who created the electric power industry. Latimer was a contemporary of other prominent Black inventors such as Norbert Rillieux (1806-1894), who revolutionized the sugar refining industry; Elijah McCoy (1844-1929), who devised automatic lubrication systems for industrial machinery, popularly known as the "real McCoy;" and Granville T. Woods (1856-1910), who became known as the "Black" Thomas A. Edison because of his contributions to the development of electrical equipment.

Latimer first worked as a draftsman in a patent office. For a number of years he was closely associated with Alexander Graham Bell, for whom he drew plans for the first telephone and assisted in preparing Bell's patent applications. After Thomas A. Edison invented the incandescent electric light in 1879, Lewis Latimer began research that led to its significant improvement. He solved the problem of the electric current rapidly destroying the incandescent light's filament by inventing a longer lasting carbon filament, which he received a patent for in 1879. The light bulb's threaded socket is another one of his inventions. In 1884, he joined the Edison Electric Light Company where he continued his research, and in 1890 wrote **Incandescent Electric Lighting,** the book that became **the guide** for lighting engineers. He helped install and supervise the carbon filament lighting system for the cities of New York, Philadelphia, Montreal and London. In 1918, Latimer became a charter member of the Edison Pioneers, "the creators of the electric industry."

Lewis Latimer had a long-term friendship with the writer and abolitionist, Frederick Douglass. His writings and their correspondence indicate that he was never out of touch with the plight of his people.

Ernest E. Just (1883-1941) -Marine biologist and teacher. He taught biology at Howard University in Washington, D.C. In 1912, he began his 27 years of research on the cell at the Marine Biological Laboratories, Woods Hole, Massachusetts. He viewed the cell as a unity, with each part having a uniquely important function. He felt that the living material surrounding the nucleus, called cytoplasm, was as important as the cell's nucleus. His research on fertilization graphically demonstrated the importance of the ectoplasm. He maintained that, "As the boundary, the living mobile limit of the cell, the ectoplasm controls the integration between the living cell and all else external to it."

Massachusetts Institute of Technology history of science Professor Kenneth Manning gives an excellent expose of Just's career in his book, B**lack Apollo • of Science.** All this was contrary to beliefs popularly held by the biologists at that time. These findings concerning the essence of life, such as the real difference between living and non-living things, the way to determine sex in advance, a new understanding of the functions of the liver, kidneys, pancreas and other vital organs, altered the opinions of scientists the world over. For his work he received many awards and honors.

- **Charles Richard Drew** (1904-1950) - Medical scientist, surgeon, and teacher. From a young boy to college, Charles Drew was an outstanding athlete. He

excelled in academics as well as in basketball, football, swimming, and track with much acclaim. He graduated from Amherst College in Massachusetts in 1926 with highest honors. Rather than choose a career with one of the excellent and highly competitive "Negro" professional teams (white professional sports teams then would not let Black men play on their teams), Drew decided to enter McGill Medical School in Montreal, Canada. In 1933 he obtained degrees in medicine and surgery. While there he became interested in blood research, particularly in the preservation blood used in transfusions. After a number of internships and college teaching positions, he came to Columbia Presbyterian Hospital in New York City and began his blood research. At that time, around 1938, blood transfusions had to be made with the donors present because of the perishable nature of blood. Over the course of his two years there, Drew discovered that plasma (blood minus its red cells) could be stored for long periods and that plasma could safely be administered to any person regardless of blood type. In 1940, upon learning of Dr. Drew's pioneering work, England and France, suffering heavy casualties during the early years of World War IL, called upon him to initiate and coordinate their military blood bank programs.

Following that success, Drew later became the first director of the American Red Cross Blood Bank. He was not in that position long however, for in 1941 he resigned following the War Department's racist "stupid blunder," of issuing a directive stating that blood of white donors should not be mixed with that of Black donors. I n his letter of resignation, Drew stated, "The disservice that has been done, has been done not only to 'Black' people, but to the cause of truth itself." Nevertheless, blood from Black enlisted persons was kept separate and made available only to Black people and in a like manner for white people. Drew returned to Howard University to teach surgery at its medical school. In 1950, while on a trip to a medical conference at Tuskegee Institute in Alabama, Dr. Drew was critically injured in an auto accident. He had lost a lot of blood and needed immediate medical attention following. Yet tragically, he encountered white racism at its ugliest - **not one** of several nearby white hospitals would provide the blood transfusions he so desparately needed, and on the way to a hospital that treated Black people, he died. It is so ironic that the very process he developed, which had been saving thousands of human lives -was made unavailable to save his life. Most people do not know, but every blood bank in the world is a living memorial to the selflessness, personal integrity, and beauty of Dr. Charles Richard Drew.

- **Moddie D. Taylor** - Chemist, mathematician, educator, consultant and writer. Integrity and dedication are the hallmarks of Taylor's personal life. Through his zealous efforts, the Chemistry Departments at Howard and Lincoln Universities

have developed sound academic programs at graduate and undergraduate levels. In 1960, he received the Annual Manufacturing Chemists' Award for being one of the "Six Best Chemistry Teachers in the U.S.A.". His tremendous impact in the field of chemistry education extends internationally to India and Liberia, where he served as a science education consultant.

On a spring day after class at Lincoln University in Missouri, one of his former students, Chicago astronomer/musician-composer Phillip Cohran, asked Moddie what was the significance of a pin (medal) he wore everyday. He related that he and a number of other Black scientists, such as Physicist J. Ernest Wilkins and Nuclear Chemists Lloyd Quarterman and George Reed, were called upon to lend their expertise on the Manhattan Project (atomic bomb) at the U.S. Department of War's (now Defense), University of Chicago. He pointed out that a number of Black scientists had studied under the pioneers of atomic energy, Albert Einstein and Enrico Fermi, who he himself studied under. One afternoon while working on the bomb project, Fermi came to him and related some difficulty. he was having over the past two weeks with the mathematical analysis of the nuclear fission process and asked Moddie if he could help solve it. Moddie went home and two hours later called Fermi with the right answer. Moddie's contributions to the development of the atomic bomb, as well as those of the other Black scientists, earned Moddie and other Black scientists a Certificate of Merit from the Secretary of War and President Harry Truman in 1945.

- **Katherine Johnson** - Physicist and mathematician. For a spacecraft's mission to be successful, the craft's trajectory and orbital parameters must be accurately defined. This is the area of Katherine Johnson's pioneering work at the National Aeronautics and Space Administration's (NASA) Langley Research Center in Hampton, Virginia. She analyzed the tracking data during the Apollo Lunar Missions. She is now developing new navigation procedures to determine more efficient ways to track manned and unmanned space missions.

- **Elmer Samuel Imes** - Astro and industrial physicist, born in 1883. The development of atomic theory has gone through a number of distinct phases, first being described in the Egyptians' theory of cosmogenesis, then among the Greeks with Democritus, among the Hindus with Vaiesheka and others, and continuing to the 19th and 20th centuries among American and European pioneers. While the theory of relativity was largely the work of one man, Albert Einstein, quantum theory, the concept of the subdivision of radiant energy into any small increments,

very small increments, quanta, and applied to numerous processes involving transference or transformation of energy in the atomic or molecular state, beginning with the work of Max Plank around 1900, was developed principally through the efforts of a number of scientists over a thirty-year period. One of those scientists was Elmer S. Imes.

Neils Bohr proved Plank's mathematical theory could explain atomic structure and atomic spectra and Imes proved Bohr's theory could also explain the rotational states of molecules. His research was published in 1919 in the Astrophysical Journal in a paper entitled, "Measurements of the Near Infrared Absorption Spectra of Some Diatomic Molecules." The consequences of his work are important in two areas of technical concern: Thermal radiation of rocket engines and radiation from certain chemical laser.

- **George W. Reed, Jr.** - Nuclear chemist and teacher. Early in his career, George Reed worked on the nuclear fission in uranium235 and thorium232 Much of this effort was spent on the previously mentioned Manhattan Project. He then extended his interest in the actinide elements to the study of other heavy elements in stony and iron meteorites. Most of his work was done at the University of Chicago and the Argonne National Laboratory. In the early 1960's his research interests broadened to the study of halogens and mercury in meteorites. In preparation for NASA's Apollo Lunar Mission in the very late 1960's and early 1970's, he initiated a program for examining trace elements in lunar samples by activation analysis. The results of his analysis of the moon rocks strongly suggested that the moon was captured by the earth's gravity sometime in the remote past rather than being ejected from the earth, a popular theory at the time. While maintaining interest in a research program on the extraterrestrial matters, Reed has turned his attention to energy-related terrestrial problems, such as acid rain from a historical perspective and geothermal problems related to permanent storage of radioactive wastes. He has received many awards. His long-standing community service is exemplified by his sincere commitment to the development of better science programs in Chicago Public Schools.

- **Rufus Stokes** (1923-1986) - Inventor and pollution control engineer. Rufus Stokes, a self-taught pollution-control engineer, designed and developed an incineration anti-pollution system. He designed this system especially for small commercial and industrial firms that must burn their trash and still meet the Environmental Protection Agency (EPA) clean-air laws. His device was proved by

independent testing firms to bean astounding 100-percent efficient. His device was issued patents in major industrial countries. Mr. Stokes mounted the device on a truck and took it around the country for demonstrations to businessmen, politicians, government officials, and colleges. The General Electric Corporation issued a publication that included him among the top scientists in American history. Yet despite the proven utility of Mr. Stokes' pollution-control device, industry never recognized it and the EPA never certified it for use. The even greater irony is that Mr. Stokes died before his 10-year dispute with the EPA concerning his invention was resolved.

- **Carl Spight** (1944-) Physicist and philosopher. Carl Spight, while working on his Ph.D. in plasma physics at Princeton University, decided to follow the path of the ancient African wisdom seekers and study philosophy. From his expanding holistic unified vision of physics, philosophy, and politics came a host of published papers and lectures, nationwide, which helped clarify technology transfer and science, technology, and society issues, particularly as they impacted on the Black community. At the 1978 meeting of the American Association for the Advancement of Science, he helped organize and chaired a symposium called "Blacks in Science, Medicine and Invention." In addition to publishing many technical papers, receiving many awards, patents, and teaching physics at Massachusetts Institute of Technology and Morehouse College in Atlanta, he has worked tirelessly to increase the numbers of Black students successfully obtaining degrees in physics through work with the National Science Foundation's Subcommittee on Minorities, Committee on Equal Opportunity in Science and Technology and several Black scientific organizations. Since September 1983 he has been Chief of Advanced Technology Programs at Sonicraft, Inc. in Chicago. His research focus there is the development of artificial intelligence (AI) and optical-signal-processing products. In 1986, he became Director of Engineering. He is a co-founder (1986) of a holistic scientific research and educational organization called the Life-Ways Sciences Institute, Inc. (LSI). LSI's approach to doing scientific research is unique in that it gives priority to long-range ethnical, moral, and safety implications of its research activities, following the tradition the ancient Egyptians established at the "House of Life" 5000 years ago. One of his research areas at LSI is the investigation of solar and planetary magnetic field reconnection phenomena and how it may affect life of earth.

- **Patrlcla Cowings** - Psychologist and aerospace medical specialist. Patricia Cowings continues the long-standing African and Hindu tradition of the use of one's thoughts to control certain involuntary physiological functions such as heart rate, blood pressure, and body temperature. As the principal investigator

in space medicine research at NASA's Space Lab Center in Houston, she has developed therapeutic programs based on certain principles of yoga to help astronauts on long-term space missions effectively combat sicknesses resulting from weightlessness. Some of her psychological exercises not only are useful in space flight, but the elderly can use them to help them cope with heart and blood pressure problems.

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- **Booker T. Whatley** (1918 -) - Horticulturist. Booker T. Whatley is America's leading expert on small-scale farming (farms with 10-200 acres of land) 65 Whatley's interest in farming grew from childhood. His greatgrandmother emerged from slavery with 640 acres of land; his grandfather, a blacksmith, was also a farmer; and his mother studied farming at Alabama A & M at Huntsville in the early 1900's, where Whatley later attended. After getting his Ph.D. in horticulture from Rutgers University in 1957, he began teaching it at Southern University in Baton Rouge, Louisiana. In 1969 he became professor of horticulture at theTuskegee Institute in Alabama. His research interest there was to develop a roster of high-yield, disease-resistant crops. His first challenge was the sweet potato. After five years of breeding and more than a million seeds, he eventually came up with the "Carver." Named for the eminent Tuskegee scientist George Washington Carver, it is considered the highest quality sweet potato today - very sweet, tasty, firm flesh, high in carotene (pro-Vitamin A), and prolific. A similar breeding program produced an outstanding grape called "Foxxy Lottie" named after his wife.

  Whatley's greatest contribution is his concept for a small farm: 1) a farm with a mixture of about 10 crops which can be altered according to yield, climate and customer demand, thus providing a year-round income, 2) having no more than three full-time workers, 3) all harvesting done by pick-your-own clubs, which is also the main market, and 4) located within 40 miles of a metropolitan area. His concept combining the best of contemporary farming technology and his generations of farming experience shelters the small farmer's investment under a unique economic umbrella-potential. Crop failure is generally limited to at most only two crops, thus income losses can not exceed 20 percent. Since about 1981, about 600 farms have started up or converted to Whatley's program. In October of 1981 he started The Small Farm Technical Newsletter, a kind of Poor Richard's Almanac for the small farmer, whose circulation has now grown to about 1200.

- **Aaron T. Curtis** (1959 -) - Electrical engineer and psychoenergeticist, Lt. Aaron T. Curtis works as part of a team conducting computer simulations of the

flying capabilities of the first reverse-winged jet fighter, the X-29A at Edwards Air Force Base in California. Curtis also is among the pioneering researchers involved in observing and recording systematically psychoenergetic (PSI) phenomena. 66 He was awarded a three-year graduate fellowship by the National Science Foundation (1979-1981) to support his statistical and computer programming work at Princeton University's Engineering Anomalies Research Laboratory. There he developed a sophisticated computer program using an Apple II computer to analyze remote viewing - that is, the human ability to acquire information about a person, place, or object(s) at a distance without using the known senses, sensory cues or any additional help.

He additionally was involved in experiments under controlled conditions of people attempting to produce psychokinesis (PK) - the ability to alter physical characteristics of materials such as metal and electronic circuits. In the tradition of the ancient Egyptian hekau (psi-engineers), Aaron Curtis, with his engineering approach to the exploration of human consciousness, looks to help people apply, with the right mental attitude and righteous intent, PK, remote viewing, and other underdeveloped human abilities, to advance not only one's personal goals in life and work, but to help others achieve as well.

- **William Edward Burghart DuBois** (1868-1963) - Sociologist, philosopher, essayist, historian, co-founder of the National Association for the Advancement of Colored People (NAACP). DuBois, who in the 19th century, studied in Germany, became Harvard University's first African-American recipient of a doctor of philosophy. He was a participant and often a leader in every single debate on racial affairs among American intellectuals during his lifetimefrom the post-Civil War, Reconstruction amendments to the civil rights movement. As one of America's most prolific essayists and also one of its earliest and best empirical sociologists and moralists, his interests and influence spanned continents and generations. DuBois pioneered the objective and factual, yet empathetic and compassionate method of empirical social science research. His 1899 work, "The Philadelphia Negro"-a 5000 person survey of urban sociology and the Atlanta University monographs on the condition of Black Americans from 1900-1910 are two of many shining examples of his brilliance. Nathan I. Huggins, professor of history at Harvard, has collected a representative sampling of DuBois' nearly century long odyssey of sensitive, intellectual research and critique of the American and International economic, political

and social order in the 1,334 page book **W.E.B. DuBois: Writings** fi[7], one of a series of volumes that constitute the Library of America-the collected works of America's foremost authors.

SUMMARY: AFRICAN-AMERICAN SCIENCE

From the horrors of slavery to present-day citizenship, African-Americans have played critical roles in America's agricultural, scientific and industrial achievement. The previous section focused on only a small fraction of African-Americans' contributions.

We surveyed significant works of African-Americans in the area of medicine, mentioning that many slaves brought with them medical knowledge from Africa. We discussed the impact of African-American craftsmanship in colonial and independent America. We then highlighted some of the hundreds of inventions made by African-Americans during the Post-Reconstruction Period of the late 19th and early 20th centuries.

Those works, plus those of George Washington Carver, Lewis Latimer, Daniel Hale Williams and African-Americans in the humanities such as the brilliant social scientist, William E.B. DuBois, along with the unsettling social conditions of that period, fertilized the hearts and minds of African-Americans with a new impetus for self-improvement and achievement. This results in an explosion of creativity and renaissance of African-American thought in the decade following World War I in art, literature, music, history, as well as science and invention. Yet, the total number of African-Americans involved in science other than medicine was still miniscule. With the social and economic climate of African-Americans significantly improved following World War II, they began attending colleges and universities in record numbers, obtaining degrees in every field from astrophysics to zoology. This was primarily a result of the G.I. Bill. Yet, running beneath the surface of all these

achievements are several undercurrents of tragedy. First, their accomplishments were made under the oppressive and inhospitable conditions of slavery, segregation, Jim Crow Laws, cultural repression and economic uncertainty. Their facilities were at best mediocre. Second, for all the awards and honors they obtained and despite the contributions they have made from colonial times to today, the stories of African-Americans in the field of science and invention remains an unwritten volume in the world book of American history. Their importance is never realized by the society at large because of their conspicuous absence in textbooks, popular science magazines such as **Discover, Omni** and **Science Digest,** and in public television programs such as **Nova.** And even more ironically, today there are more than 90,500 African women and men in scientific, engineering and technological positions, yet because of this exclusion they are even unknown in their own communities.

The solving of problems in any human society is a function not only of the use of accumulated knowledge, but of creative and innovative thinking by particular individuals. Were it not for the existence of African-Americans of genius, where would America be?

CONCLUSION

Above all, what emerges from this baseline essay is the vision of African people as being the wellspring of creativity and knowledge on which the foundation of all science, technology and engineering rests and draws continuing inspiration. Presented here was information which is astonishing-only because our curricula, from grade school to college, have shrouded us in ignorance, flooding generations of our children's minds with an extremely narrow band of light from the broad spectrum of human accomplishments.

The incorporation of any new information into a school's curriculum is a formidable task, yet in this case there is a sense of urgency.[68] Maybe someday the educational industry, the print and electronic media, upon discovering the high hidden costs of ignorance, will put out materials, information and programs that would present a truer picture of the discovery and development of science, technology and engineering. We don't have to wait however.

We have, right now within our grasp, a chance to do just that; we can begin to plant the seeds of this knowledge for a harvest of lasting benefits-for today's and future generations of our children-a new level of cultural understanding, appreciation and respect.

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APPENDIX A – Figures 1 THROUGH 30

FIGURES FOR AFRICAN-AMERICAN SCIENCE BASELINE ESSAY

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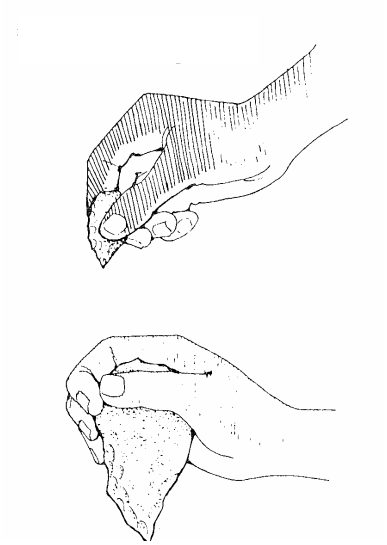
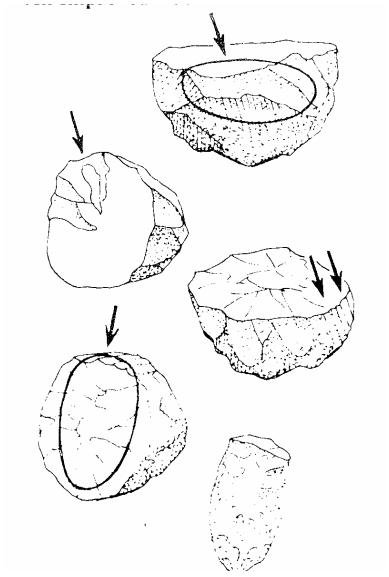
Figure 1
THE FIRST TOOLS

a 2.0 Million Years Ago
Tools Handling



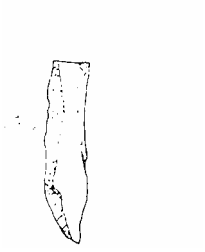
Small flakes held by homohabilis could cut through the skin and flesh of a dead animal. A hand ax carried in the palm of homo erectus about 1.9 million years ago made a characteristic hunting weapon.

b. 100,000 Years Ago
An Improved Tool

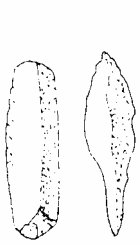


The Levallois technique was perfected and widely adopted 160,000 years ago. This tool was created by striking a well-formed, economical tool from a prepared core of stone.

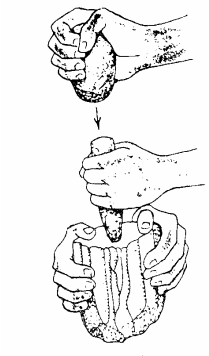
c Tools from 2 million to 40,000 Years Ago



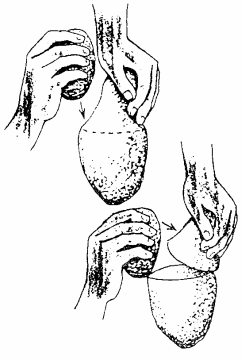
2 Million years before present



I Million years before present



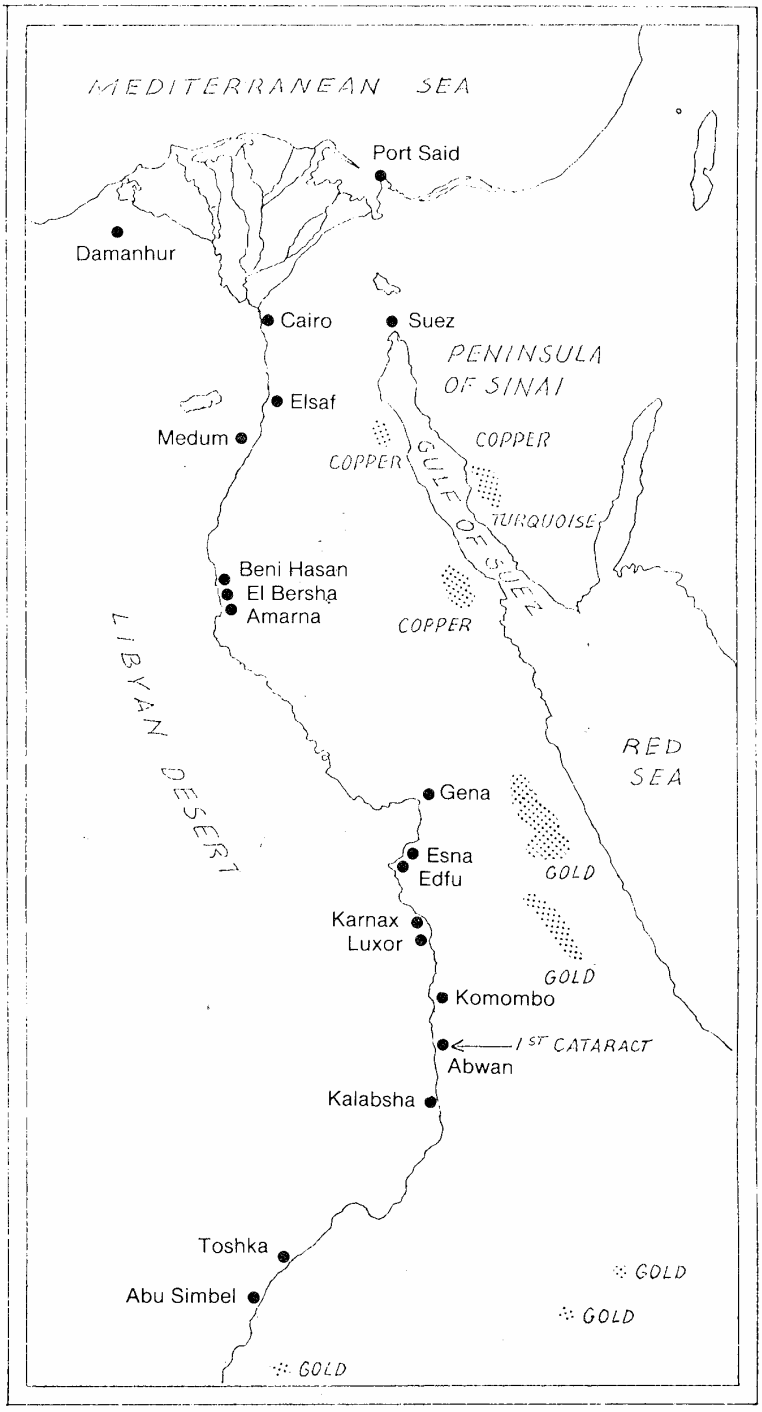
200,000 years before present



40,000 years before present -- stone razors

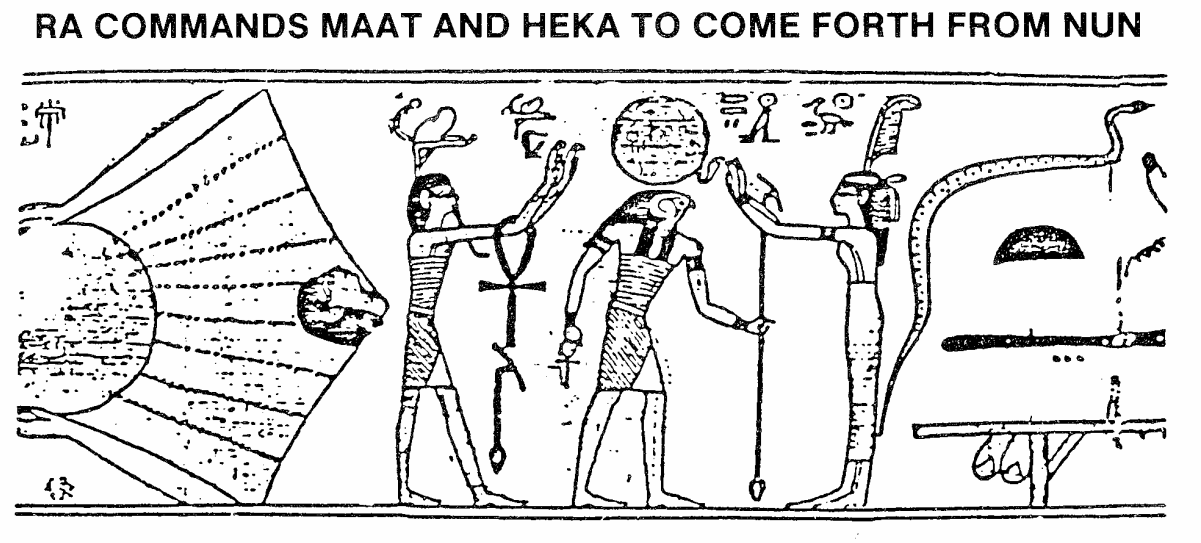
Figure 2

MAP OF THE NILE VALLEY



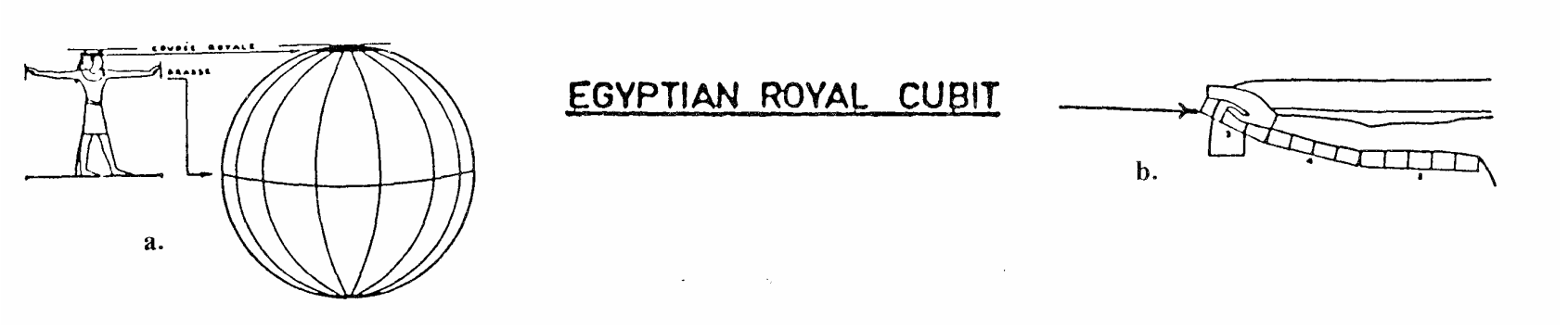
Map of the Nile valley below the first Cataract, showing principal mining sites.

Figure 3
EGYPTIAAN COSMOLOGY



From **Nun** (man with raised arms holding disc [universe]), icon for the infinite, primordial ocean of unbounded-no-space/no-time, the **Neter** (divine principle) **Ra** (hawk-headed man holding cross-type icon', an ankh [life principle] and the staff of authority) commands the **Neter** (divine principle) **Maat** (woman with feathered headress) representing order, truth, and cosmic consciousness and the **Neter** (divine principle) **Heka** icon for the trans-material energy (man with hind-quarter of lion atop his head, holding an ankh and the staff of authority) to bring forth the universe as bounded space/time for its `first time.'

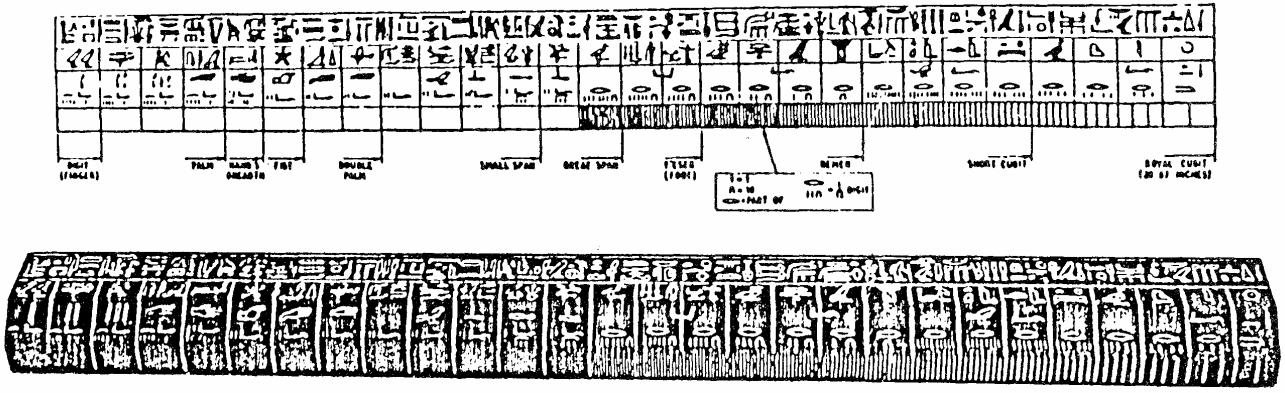
Figure 4
PERSPECTIVES OF THE EGYPTIAN ROYAL CUBIT



Royal Egyptian cubit of Memphis. It was divided Into 7 palms of 4 fingers each, for a total of 28. The basic unit from which this cubit Is derived is the foot of 300 millimeters. One and a half of these feet made a cubit of 450 illimeters, divided Into 6 palms of 4 fingers, for a total of 24 fingers. The royal Cubit was obtained by the addition of one extra palm, for a total of 7, or 28 fingers, the equivalent of 525 millimeters.

Slecchini points out that a septenary unit was common to Mesopotamia, Egypt and Greece, because It allowed simple solutions to problems of practical measurement. With a ^ of 22/7, it was simpler to have a septenary cubit; a square of side 7 was considered to have a diagonal of 10, and a square of 10 as having a semidiagonal of 7.

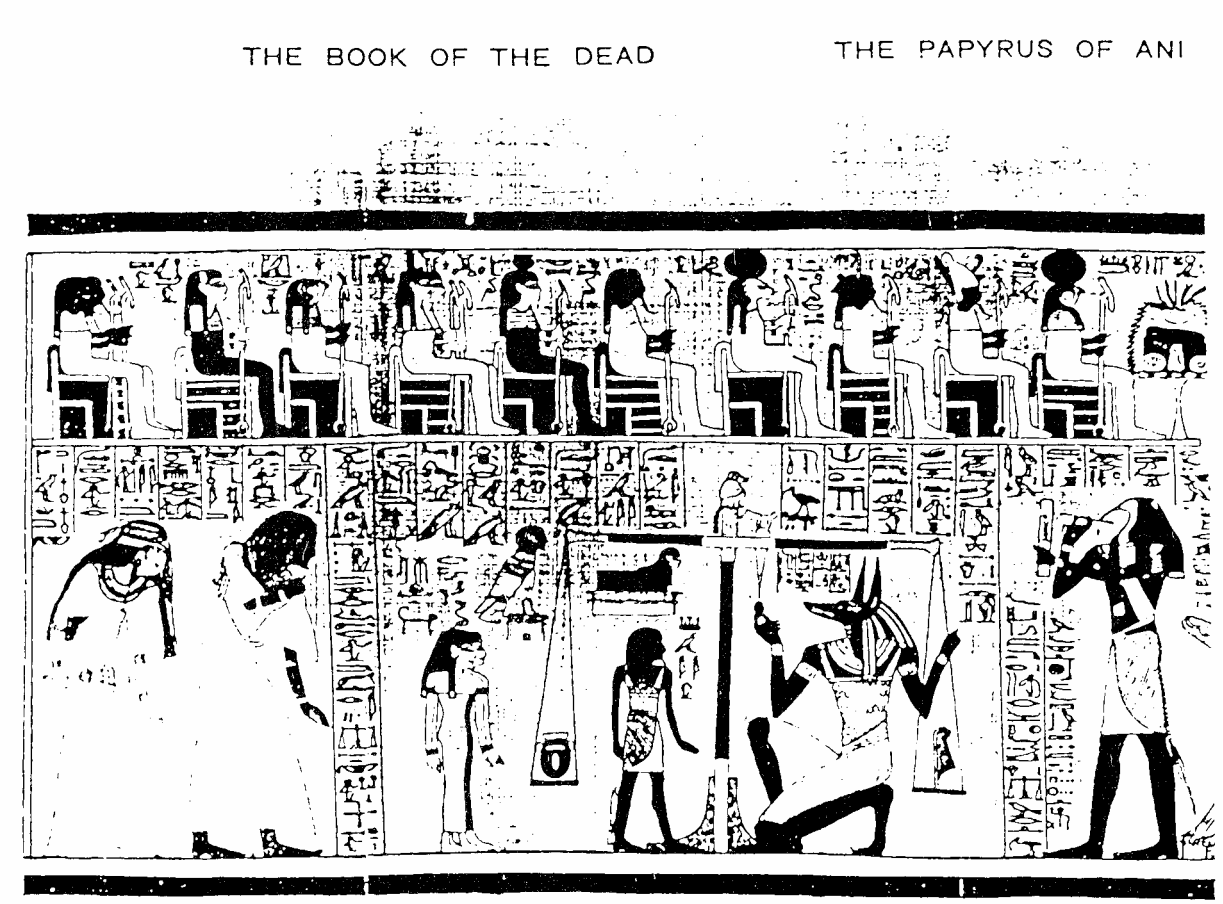
c. THE CUBIT OF KING AMENHOTEP I 1559-1539 B.C. 18th DYNASTY
ORIGINAL IN THE LOUVRE PARIS



A possible division of an Egyptian measuring-rod. Courtesy M. J. Puttock B.Sc., National Standards Laboratory, C.S.I.R.O., Sydney, Australia.

Figure 5

WEIGHING OF THE HEART FROM THE BOOK OF THE DEAD



-Vignette: Above, twelve gods seated in order, as judges, before a table of offerings. Below, the Psychostasia, or Weighing of the Conscience: the jackalheaded Anubis trying in the Balance the heart (conscience) of the deceased against the feather symbolical of Law ; on the left, Ani and his wife in an attitude of devotion ; on the right, the ibis-headed Thoth, the scribe of the gods, noting down the result of the trial, and behind him the monster Amemit, the Devourer. On the left of the bal. ance,Shai (Destiny) with the two goddesses Renenit and Meschenit behind him ; above them, the soul of Ani, as a human-headed hawk,and the symbol of the cradle.

Text : On the left, the address of Ani to his heart ; on the right, the sentence of acquittal.

Figure 6

EMPLOYING THE MERKET

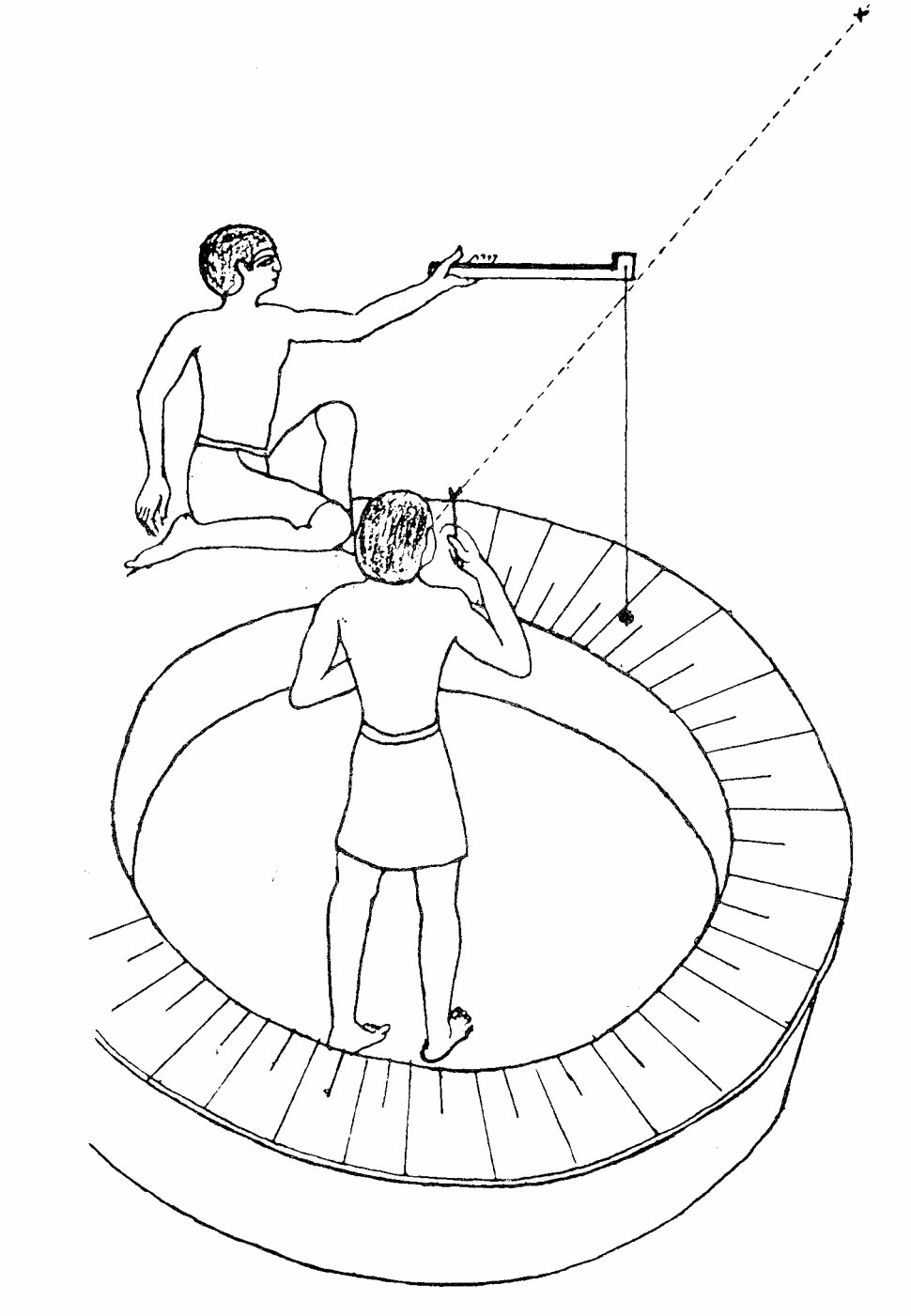
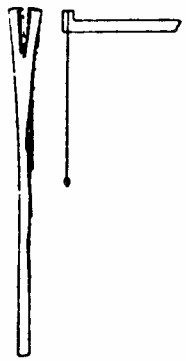
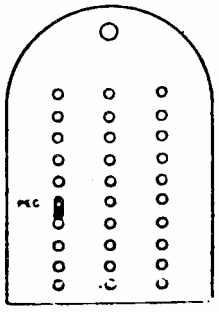


Figure 7

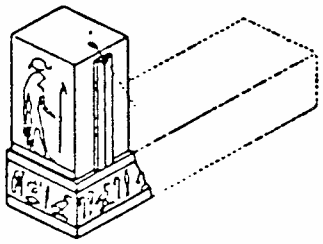
EGYPTIAN ASTRONOMICAL INSTRUMENTS



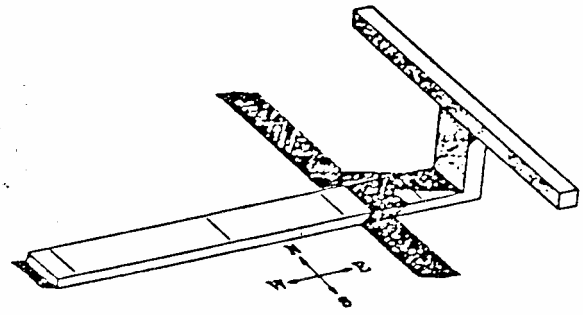
a. Merket



b. Peg Calendar

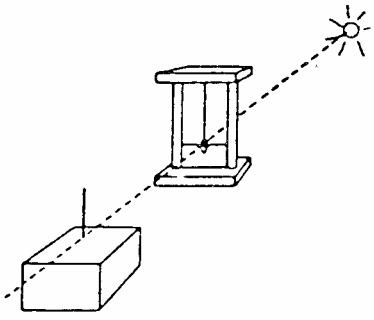


c. Water Clock



d. Shadow Clock

e. Solar Gate



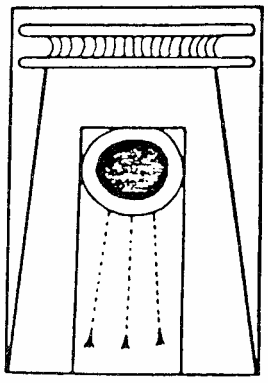
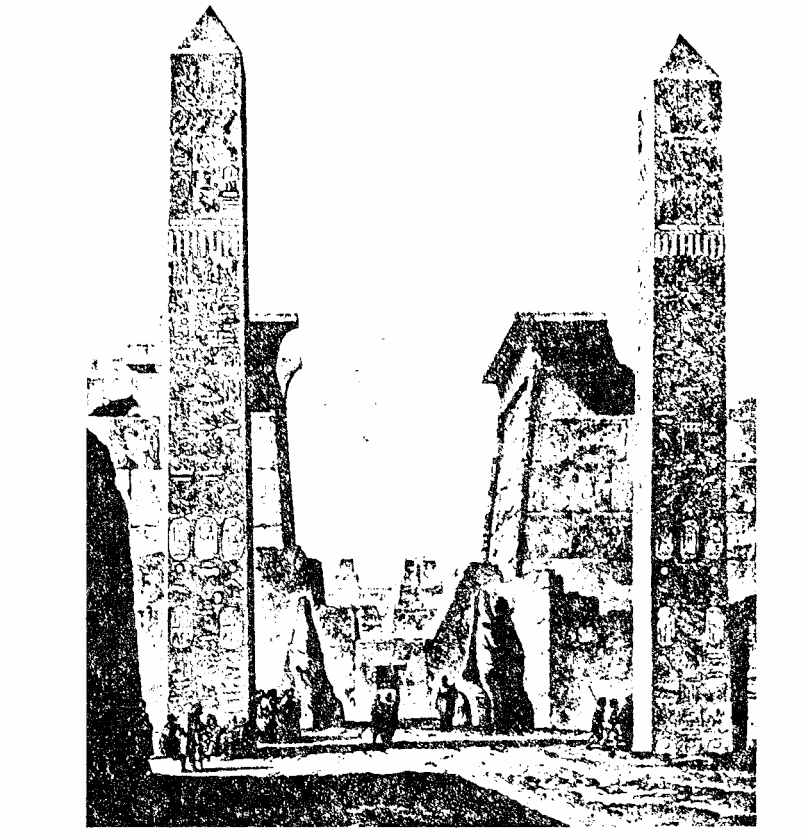


Figure 8

OBELISKS OUTSIDE THE TEMPLE OF AMON-RA AT KAMAK



To compute the polar circumference of the earth the ancients used the sun and the shadows cast by obelisks. To compute the equatorial circumference they observed the passage of stars across fixed points such as obelisks. For the polar circumference they needed merely to measure the distance between two obelisks a few miles apart and the difference in the length of the shadows of the obelisks.

Figures 9 - 11

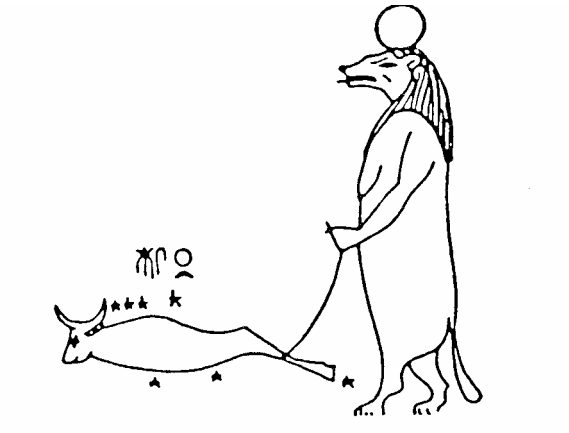
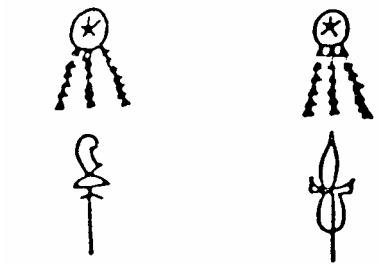
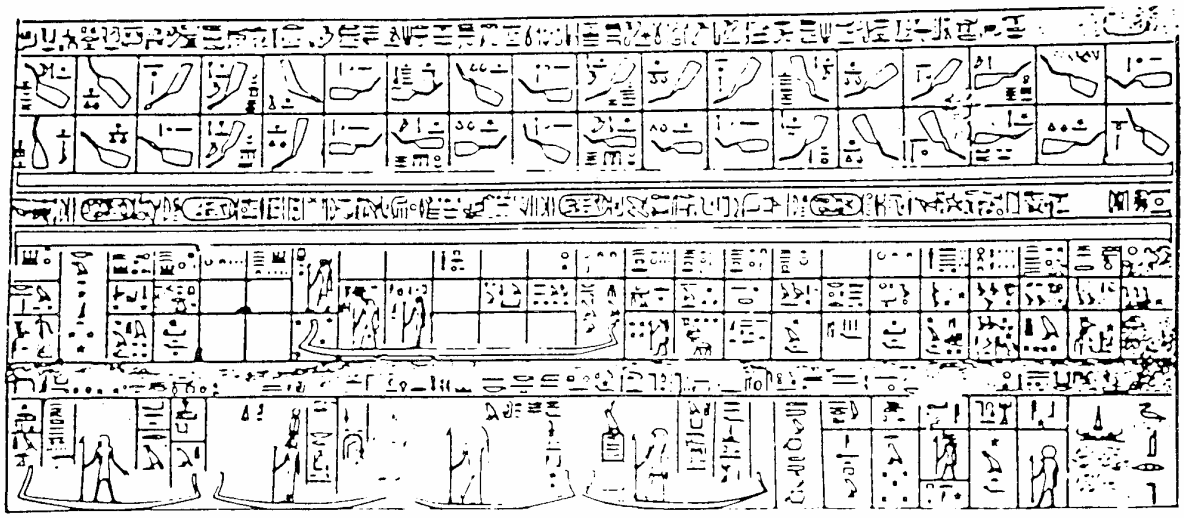


Figure 9
POLAR CONSTELLATIONS



On the left is the representation from the Temple of Horus si Edfu of Venus as the evening star. From the same temple, on the right. is the symbol of Venus as as the morning star.

Figure 10
VENUS



The inner face of a lid from a granite sarcophagus from hom Abu Yasin, dated to the 39th dynasty (about 359-341 BC). The lower registers record the hourly decans, planets and attendant deities. It is especially noteworthy for the upper register which records monthly variations of the Polar constel!ation usually represented by the Bull. Here only the foreleg of the Bull svmbolizes the constellation as it rotates around the pole. The accompanying text equates Osiris, god of the dead and of resurrection, with this heavenly Bull.

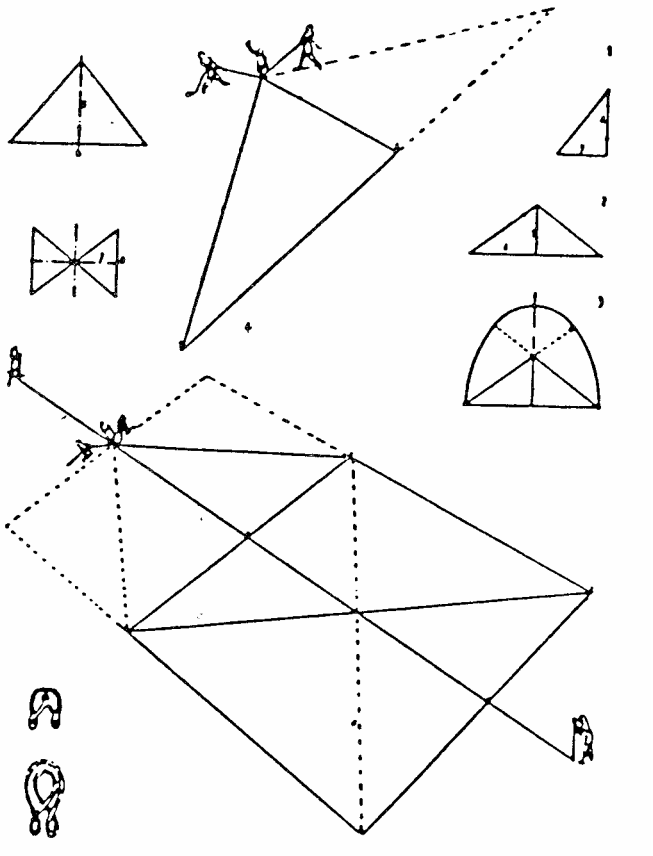
Figure 11

POLAR CONSTELLATIONS

Figures 12 - 13
SITE SURVEYING: THE FOUNDATION CEREMONY

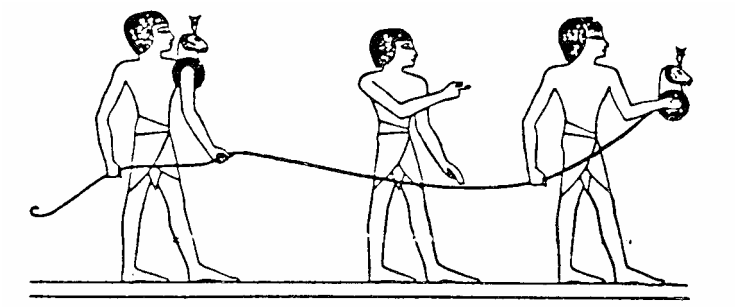
Seshet:
Lady of Writings and Lady of the Builders

Figure 12



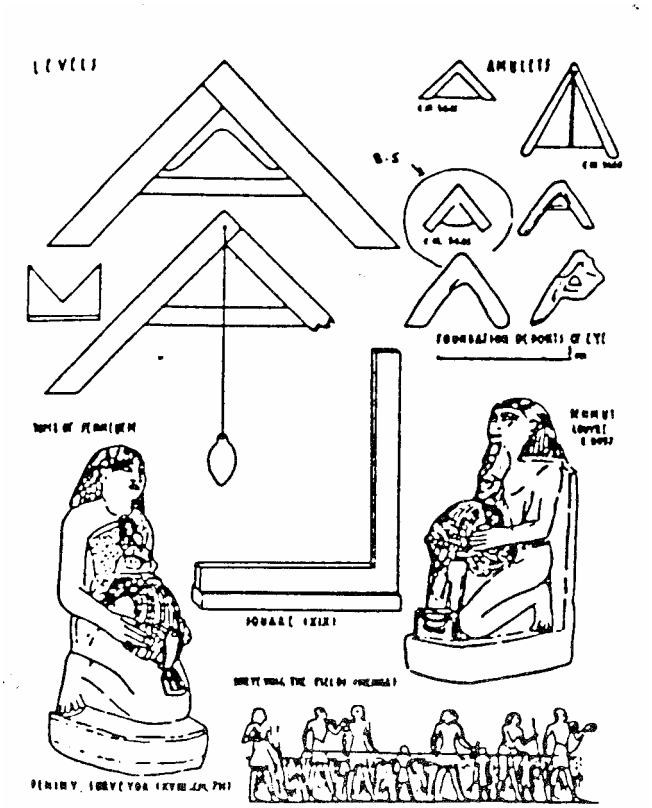
"Stretching the Line Cord"

Figure 13



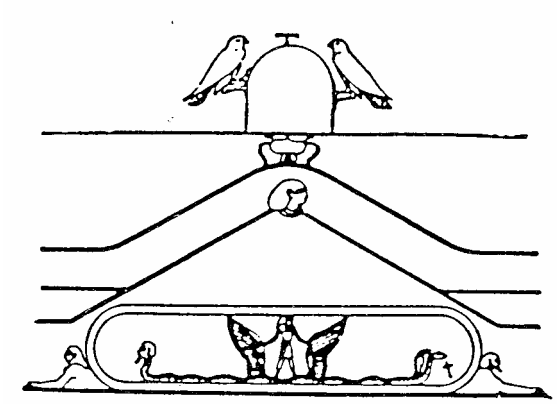
Surveyors: the roll of the cord is crowned with an Amonian ram wearing the uraeus.

Figure 14



Instruments of design® ***levels, triangles*** square, ***and*** knotted cord.

Figure 15



Egyptian papyrus depicting Sokar, the god of orientation. The gadget op top of the *omphalos* is a standard Egyptian measuring ruler (and also the symbol for the sky). The two pigeons facing each other are the standard glyph for the laying out of parallels and meridians.

Figure 16

EGYPTIAN KNOWLEDGE OF THE 3-4-5 "PYTHAGOREAN" TRIANGLE

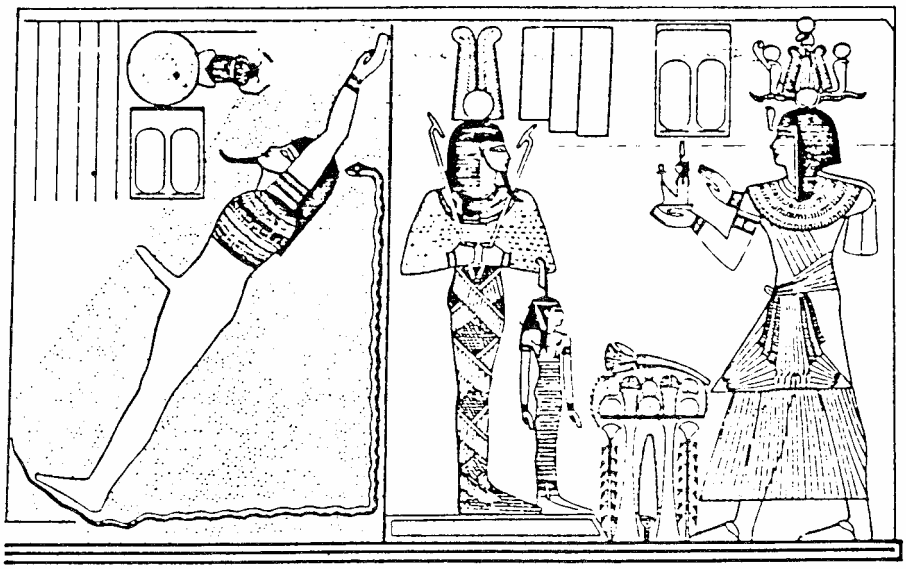


Figure 17a

Ramses IX, the sacred triangle. and the function *Pi.* (Thebes)

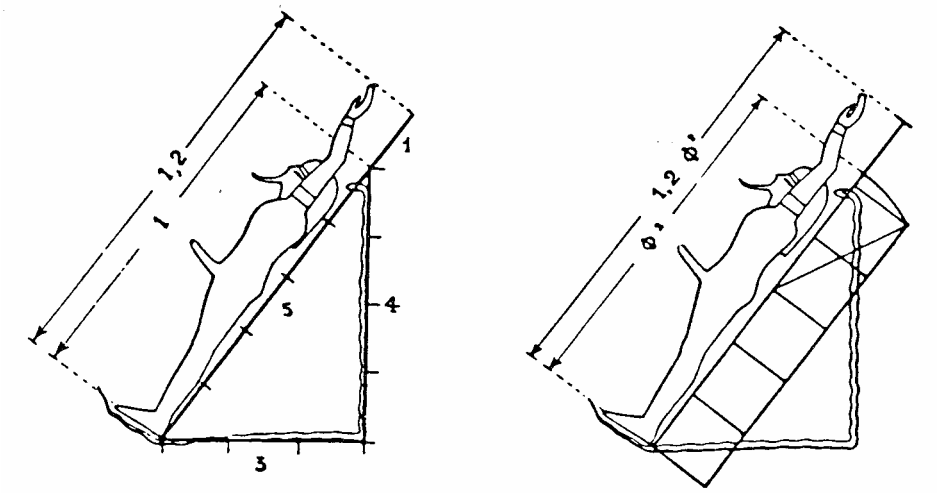
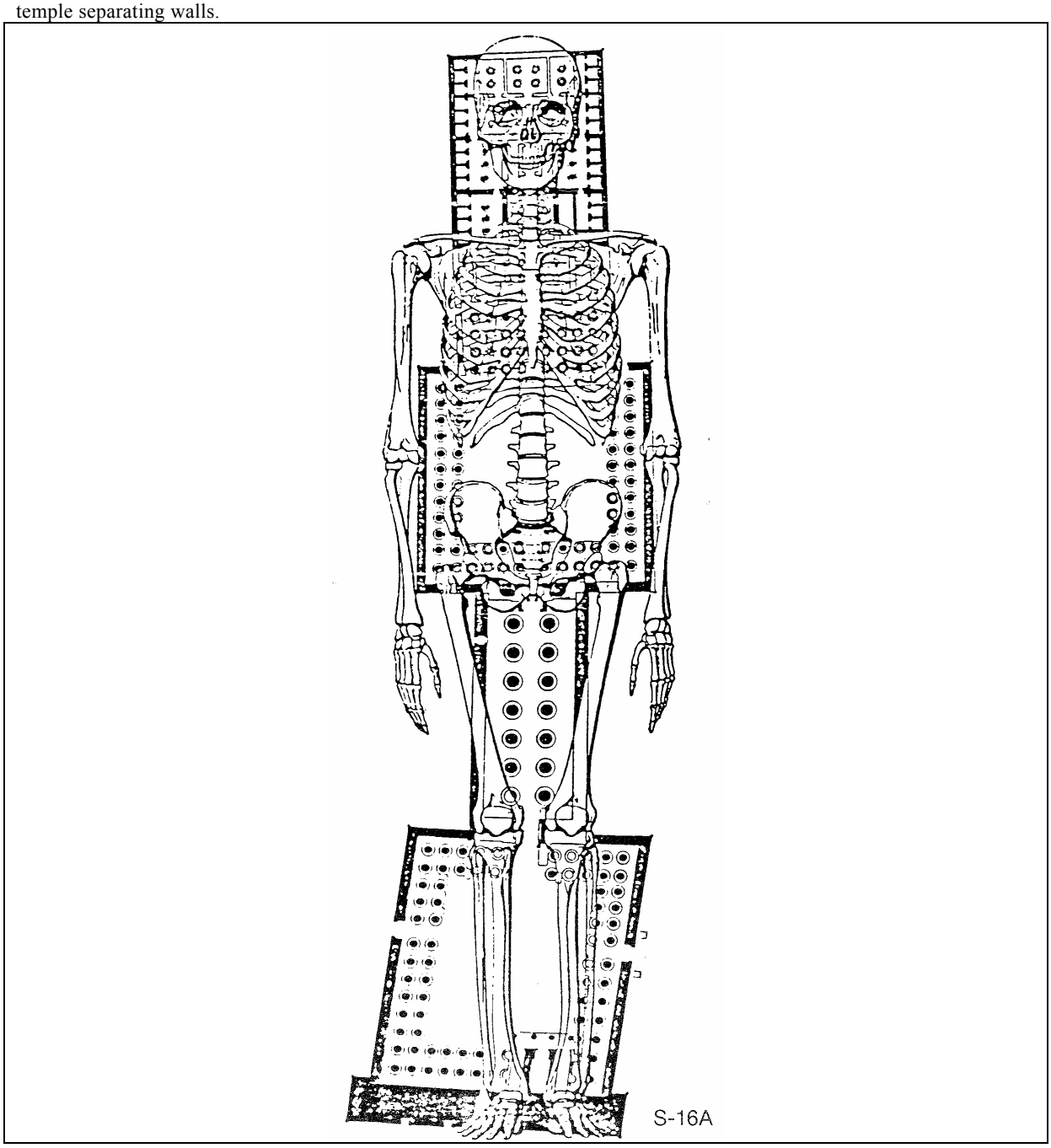


Figure 17b

On the left, layout of principle: the King as hypotenuse of the sacred triangle. On the right, the King has a value of 0^{1} and 1.2 $_{-2,}$ equaling *Pi.* **In** reality, the height of a man is four cubits.

Figure 18
SUPERIMPOSED SKELETON ON THE TEMPLE AT LUXOR

Just as the various sections of the human hody have a harmonious relationship to each other; those same relationships are incorporated in proportions of the 'Temple. Note the close accord between human joints and the temple separating walls.



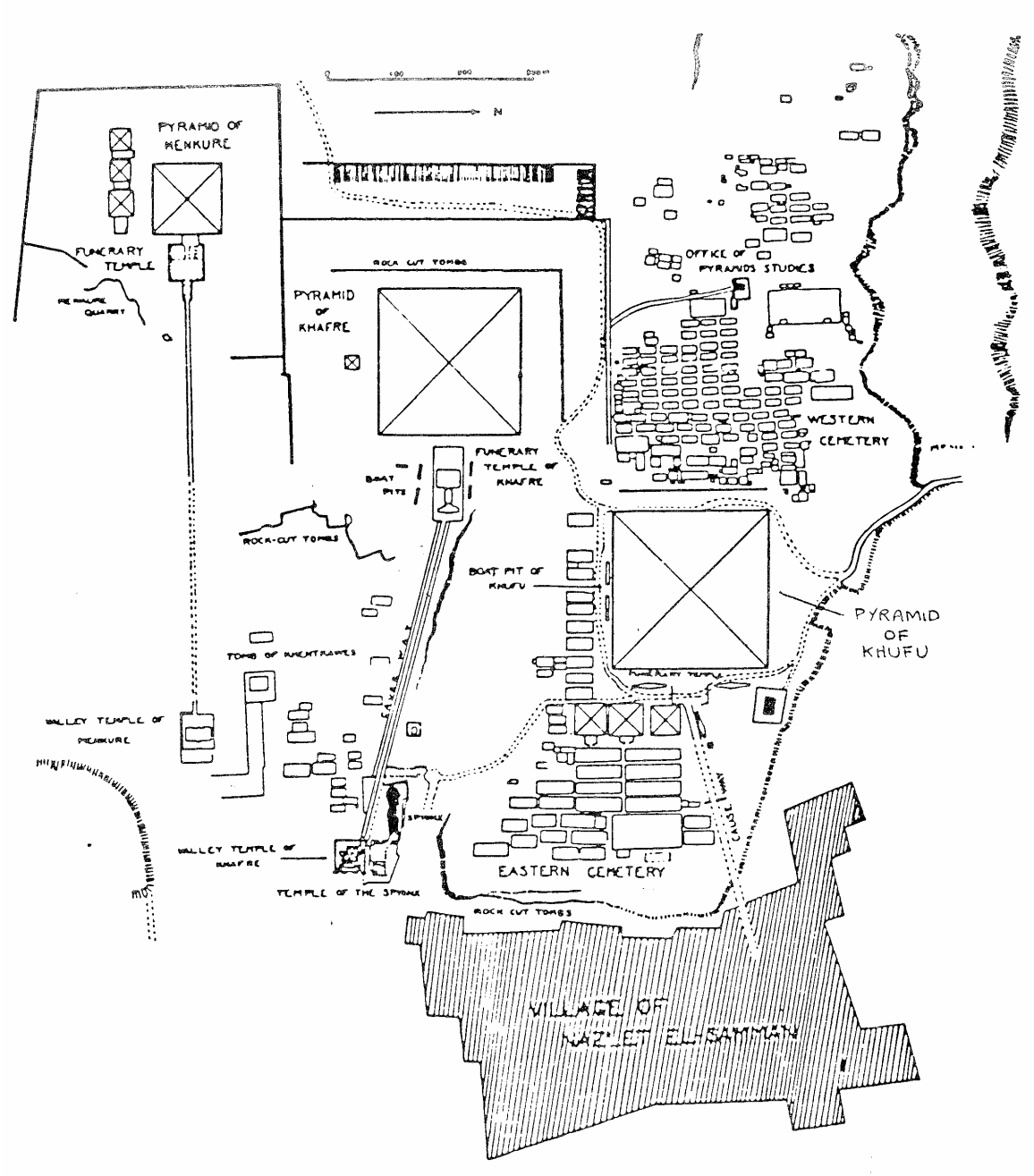
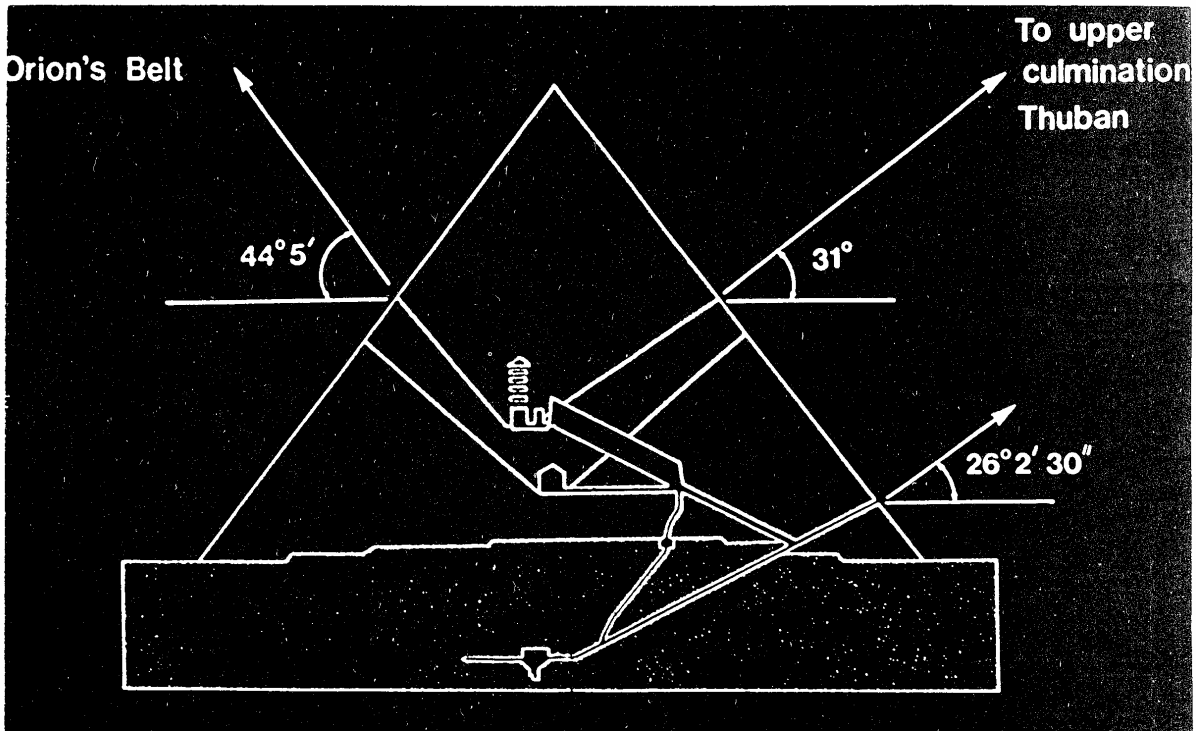


Figure 19

'THE GIZA NECROPOLIS

Figure 20



The Great Pyramid of Giza

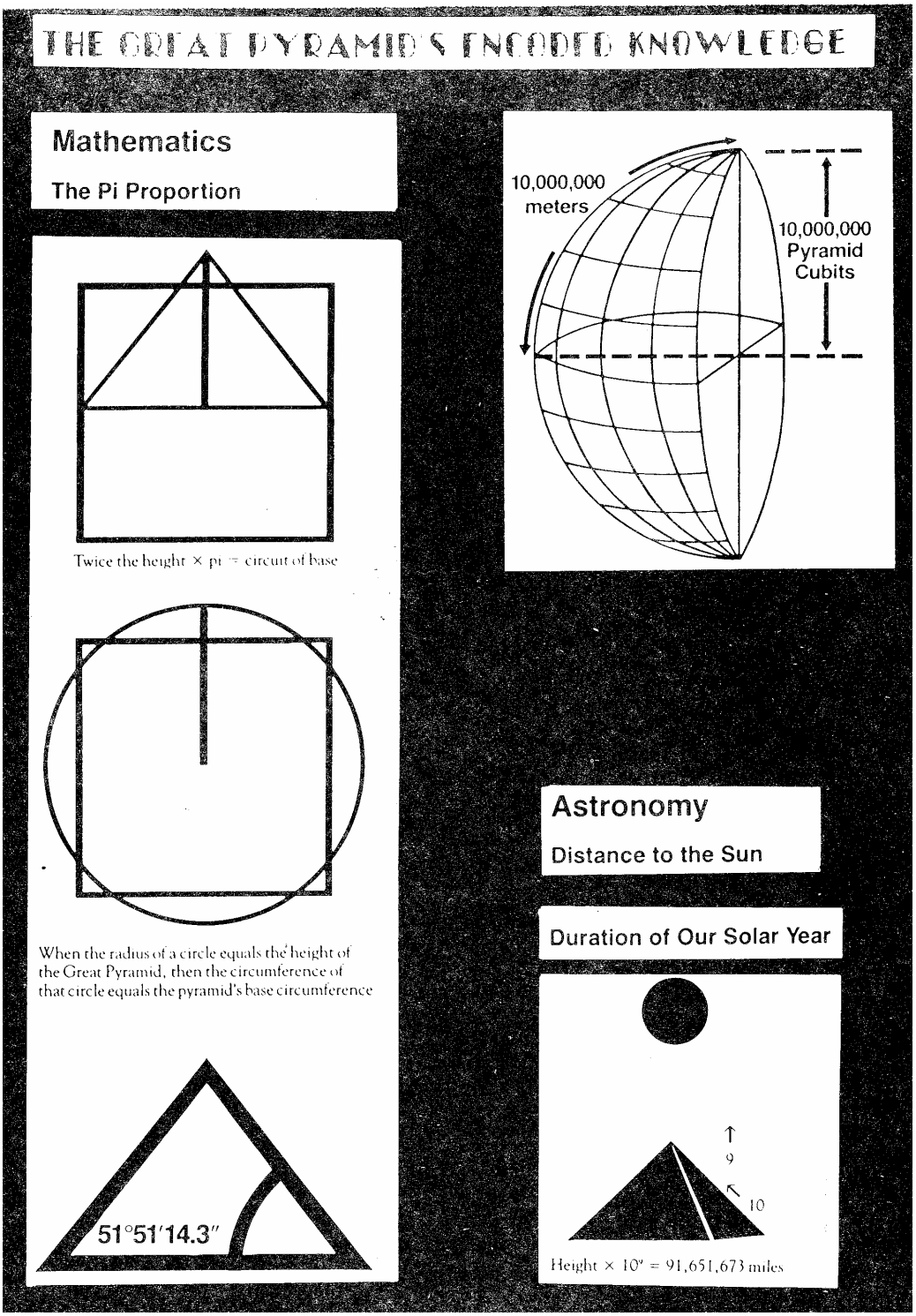
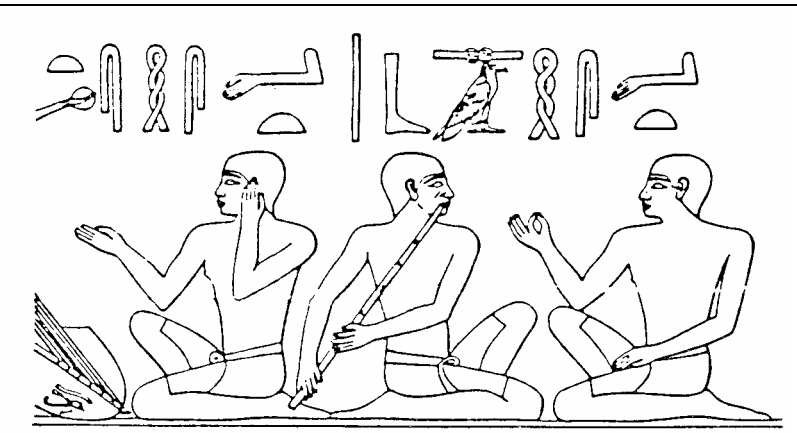

THE GREAT PYRAMID'S ENCODED KNOWLEDGE
Mathematics
The Pi Proportion
Twice the height × pi = circuit of base
When the radius of a circle equals the height of the Great Pyramid, then the circumference of that circle equals the pyramid's base circumference
51°51'14.3"
10,000,000 meters
10,000,000 Pyramid Cubits
Astronomy
Distance to the Sun
Duration of Our Solar Year
9
10
Height × 10⁹ = 91,651,673 miles

Figure 21

THE SCIENCE OF SOUND

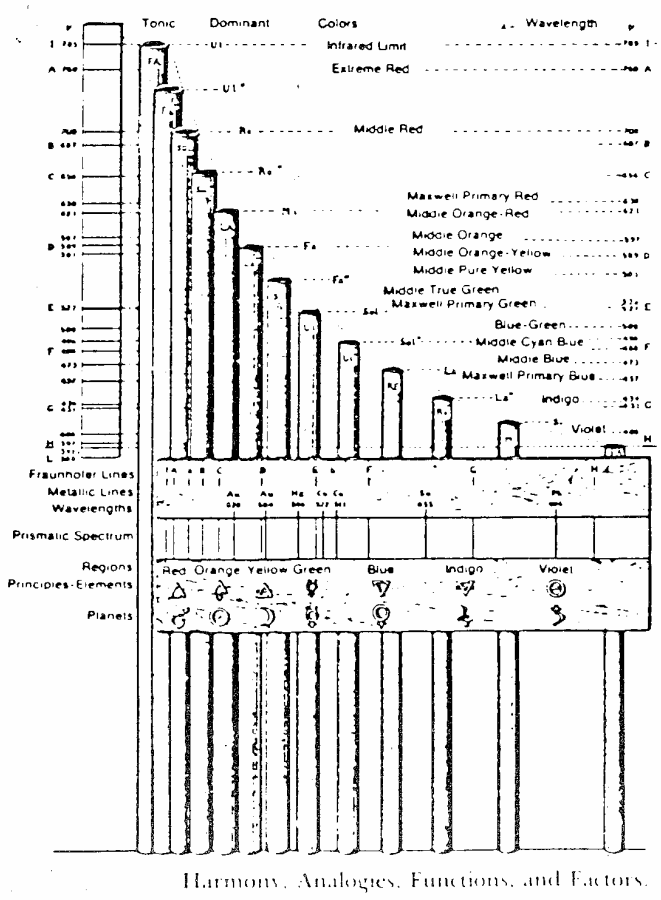


Psalming with the harp, singing and flute playing.

Figure 22

Bes: the Neter (divine principle) for music

Figure 23



Harmony, Analogies, Functions, and Factors.

Figure 24

Egyptian Terms for Brain Anatomy

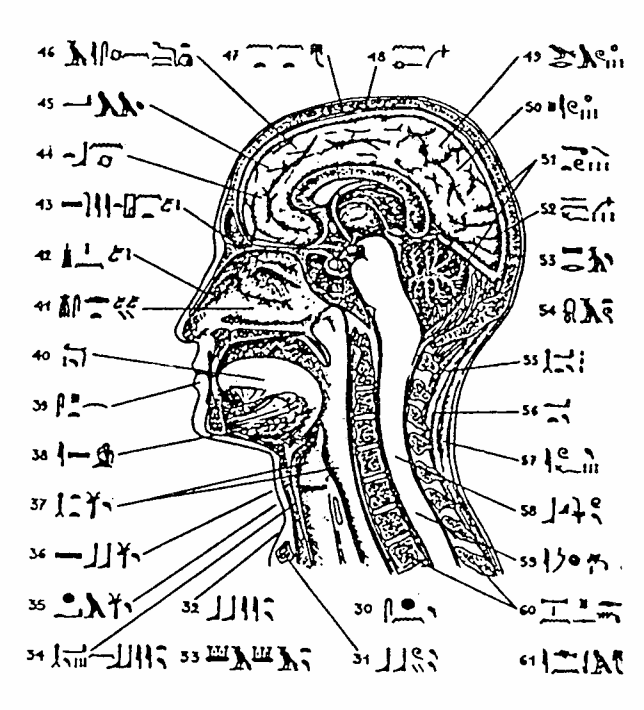
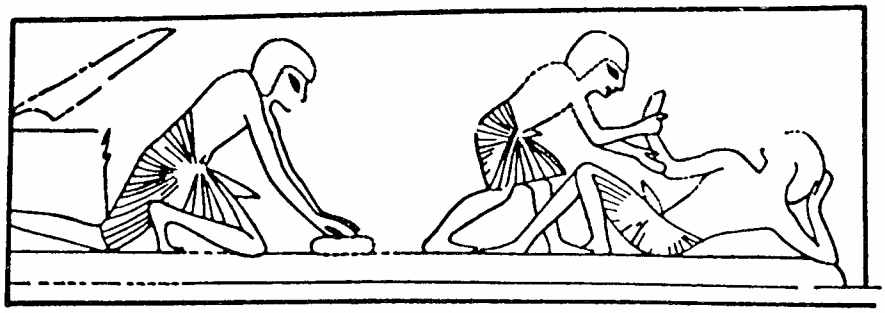


Figure 25



Details from works of the architect Ipuy – A person sets a dislocated shoulder.

Figure 26

Figure 27

A RECONSTRUCTED 2000 YEAR OLD ANCIENT BATTERY

FOUND IN IRAQ - SIMILAR TO EGYPTIAN ONES

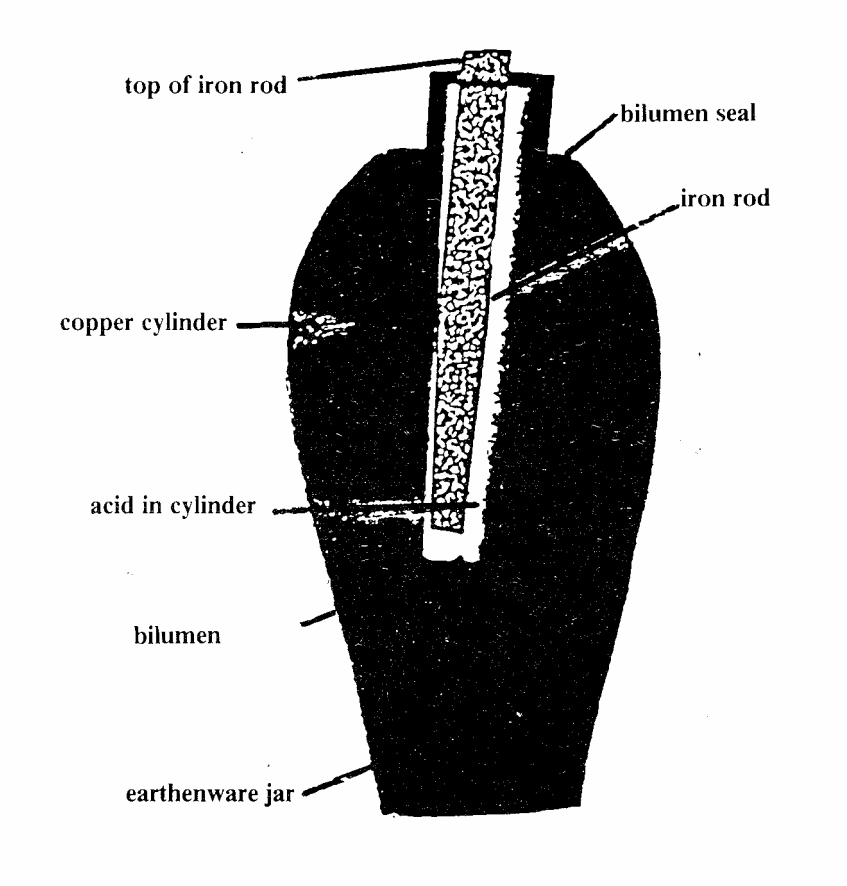
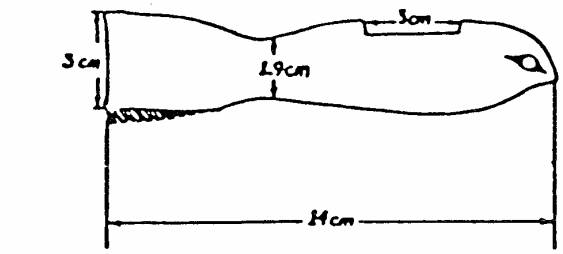
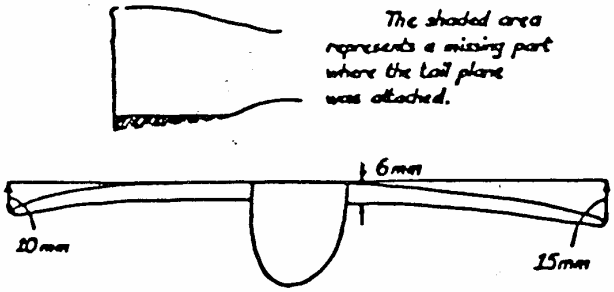


Figure 28

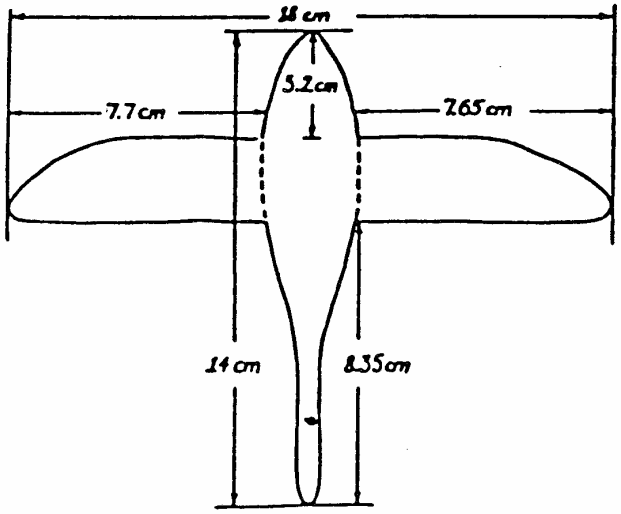
A 2,000-YEAR-OLD MODEL GLIDER



Side view (right side)



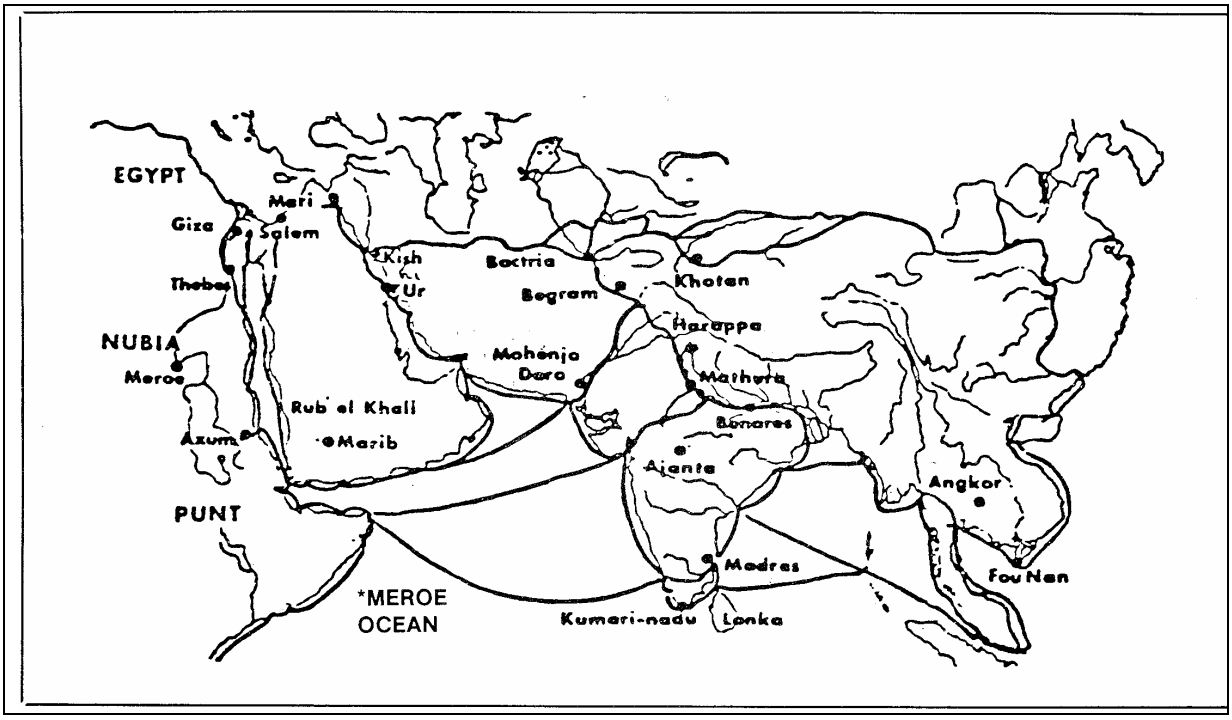
This diagram shows the tapering wings and the dihedral angles



Plan of the model (ventral view)

Figure 29

COMMERCIAL LAND AND SEA TRADE ROUTES OF ANTIQUITY

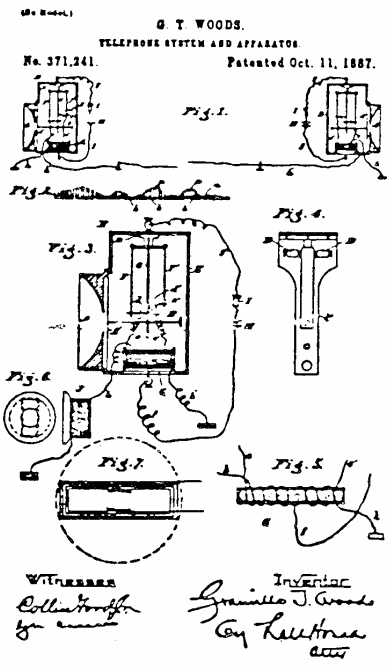


***Meroe Ocean now called Indian Ocean**

APPENDIX B
PATENTS OBTAINED BY AFRICAN-AMERICAN INVENTORS

Page No.	Illustration No.	Inventors Patented Invention	African-American Inventor
S-118	1	Telephone System & Apparatus	G.T. Woods
	2	Type-writing Machine	L.S. Burridge & N.R. Marshman
S-119	3	Breathing Device	G.A. Morgan
	4	Corn Silker	R.P. Scott
	5	Pencil Sharpener	J.L. Love
S-120	6	Apparatus for Transmissions o Messages by Electricity	G.T. Wood
	7	Steam Table	G.W. Kelley
S-121	8	Lemon Squeezer	J.T. White
	9	Device for Rolling Cigarettes	J.A. Sweeting
	10	Cap for Bottles	A.E. Long & A.A. Jones
	11	Window Cleaner	A.L. Lewis
S-122	12	Lasting Machine	J.E. Matzeliger
	13	Street Sweeper	C.B. Brooks
S-123	14	Child's Carriage	W.H. Richardson
	15	Guitar	R.F. Flemming, Jr.
S-124	16	Parcel Carrier for Bicycle	J.M. Certain
	17	Bicycle Frame	I.R. Johnson
S-125	18	Railway Brake Apparatus	G.T. & L. Woods
	19	Elevator	A. Miles
	20	Steam Boiler Furnace	G.T. Woods
S-126	21	Air Conditioning Unit	F.M. Jones
	22	Refrigerator	J. Stanard

1



UNITED STATES PATENT OFFICE.

GRANVILLE T. WOODS, OF CINCINNATI, OHIO, ASSIGNOR TO THE WOODS ELECTRIC COMPANY.

TELEPHONE SYSTEM AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 371,241, dated October 11, 1887.

Application filed June 1, 1886. Serial No. 204,148. (No model.)

To all whom it may concern:

Be it known that I, GRANVILLE T. WOODS, a citizen of the United States, residing at Cincinnati, Ohio, have invented new and useful Improvements in Telephone Systems and Apparatus, of which the following is a specification.

My invention relates to a method or and apparatus for the transmission of articulate speech and other sounds through the medium of electricity, its object being to obtain an increased force of transmission of the impulses controlling the action of the diaphragm at the receiving end; also, to obviate the disturbing effects now attributed to induction from neighboring lines.

The nature of my invention will be more clearly understood from the subjoined description, in connection with the accompanying drawings, forming part of this specification, in which the parts referred to are indicated by letters of reference.

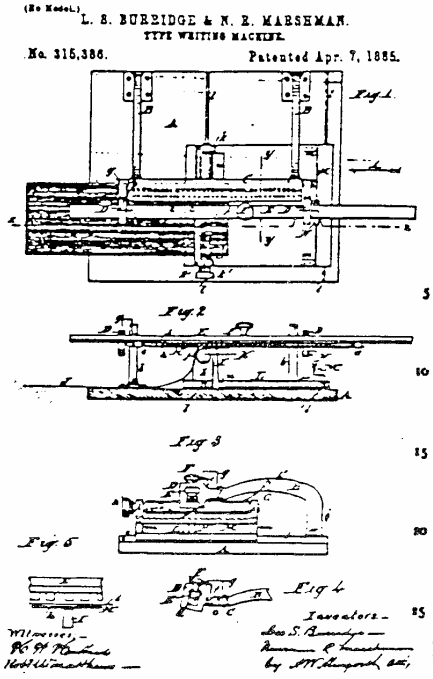
In the drawings, Figure 1 is a diagram of the entire system arranged for use; Fig. 2, a graphical representation of the electrical current as modified and utilized in the transmission of speech or sound by my invention; Fig. 3, an enlarged vertical cross-section of the transmitting-instrument; Fig. 4, a detached side elevation of the "vibrator;" Fig. 5, a diagram explanatory of the construction of the induction-coil and connections; Figs. 6 and 7, detail views of the receiving instrument.

My invention differs from the ordinary methods of electrical transmission of speech in two essential particulars: First, I employ in the primary or local circuit under control of the sending-diaphragm a non-continuous or intermittent current, which by the action of the sending-diaphragm is alternately shunted by media of varying conductivity in opposite directions through the primary of an induction-coil, producing, second, alternating currents of opposite polarity in the line-circuit.

By the first-mentioned feature I obtain a current of far greater inducing strength in the primary of the coil, and by the latter a reversal of the polarity of the diaphragm in the receiving-instrument, whereby the diaphragm is both attracted and repelled, thereby increasing the range and force of its vibrations and producing more vigorous air-vibrations and louder sounds. I also obtain a more forcible transmitting-current and the counteraction of static effects, whereby I am able to transmit through longer distances.

An explanation of the principles involved will be given in connection with the following description of the form of apparatus illustrated in the drawings. A designates the mouthpiece, and A' the ordinary diaphragm, of a transmitting apparatus. In rear of the dia-

2



UNITED STATES PATENT OFFICE.

LEE S. BURRIDGE AND NEWMAN R. MARSHMAN, OF NEW YORK, N. Y.

TYPE-WRITING MACHINE.

SPECIFICATION forming part of Letters Patent No. 315,386, dated April 7, 1885.

Application filed March 28, 1884. (No model.)

To all whom it may concern:

Be it known that we, LEE S. BURRIDGE and NEWMAN R. MARSHMAN, citizens of the United States, and residents of New York, in the county and State of New York, have invented certain new and useful Improvements in Type-Writers, of which the following is a specification.

The object of our invention is to provide an inexpensive and yet complete type-writer of but very few parts, not liable to get out of order, requiring for its operation as few movements as in the case of expensive machines now in use, and which will admit of printing a sheet of paper of any length without the necessity of coiling or folding the same.

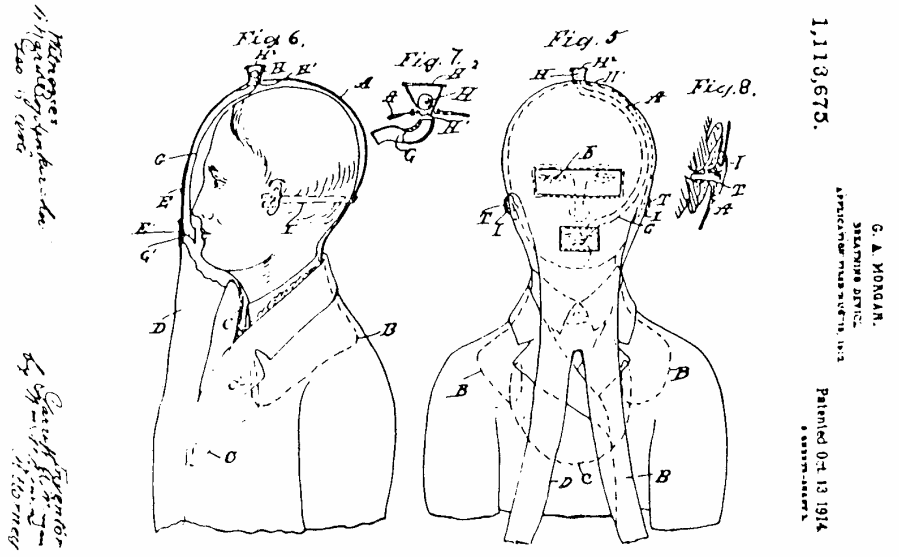
The invention consists in the combination, with a stationary letter-plate, of a type-plate fitted to slide parallel with the said letter-plate in hinged or only vertically-movable supports, a stylus rigid upon the said type-plate, an impression-surface, and means for feeding the paper the proper distance between the letters by the vertical movement of the type-plate.

It also consists in the combination of a laterally-movable type plate carrying below its type-surface a plate perforated opposite to the type-face of each letter, and an ink-ribbon interposed between the type-surface and the said perforated plate, with a stationary impression-stud, and means for moving the paper over the said stud.

It also consists in the combination, with the letter-plate and type-plate, of one or more supports, each consisting of a horizontal or overhanging arm or reach having at one end the aforesaid plates, and secured at its other end by a downward-projecting branch to the bed-plate or main support of the machine, as will be hereinafter described and claimed, with reference to the accompanying drawings, in which—

Figure 1 represents a top or plan view of our improved type-writer. Fig. 2 is a longitudinal vertical section of the same, taken on the line *x x* of Fig. 1, as seen from the front. Fig. 3 is an end elevation of the same, seen in the direction of arrow 1 in Fig. 1. Fig. 4 is a detail cross-section of the letter-plate and type-plate, as seen in the direction of arrow 1. Fig. 5 is a partial detail view, on a larger scale than the previous figures, to illustrate the operation and arrangement of the type-plate, ink-ribbon, perforated plate, and impression-stud.

3

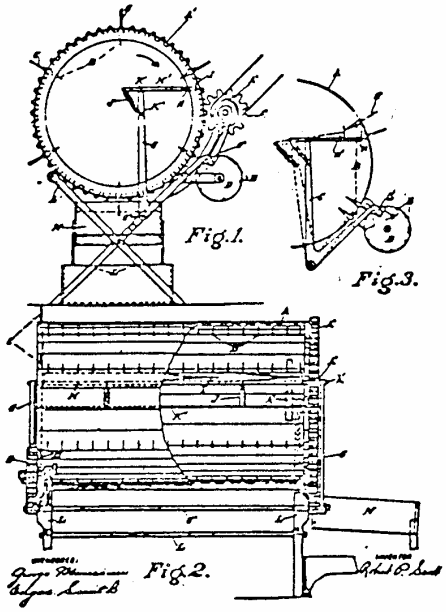


4

(No Model.)

R. P. SCOTT.
CORN SILKER.

No. 524,223. Patented Aug. 7, 1894.

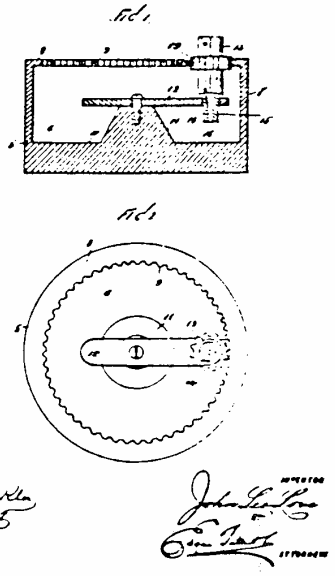


5

(No Model.)

J. L. LOVE.
PENCIL SHARPENER.

No. 594,114. Patented Nov. 23, 1897.



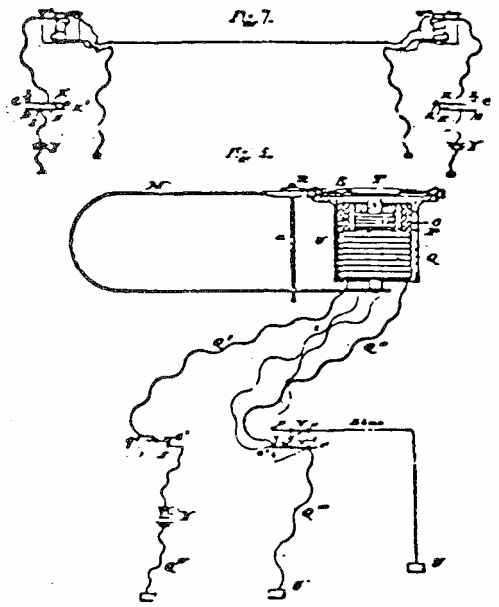
6

(No Model.) 3 Sheets—Sheet 2.

G. T. WOODS.

APPARATUS FOR TRANSMISSION OF MESSAGES BY ELECTRICITY.

No. 315,368. Patented Apr. 7, 1885.



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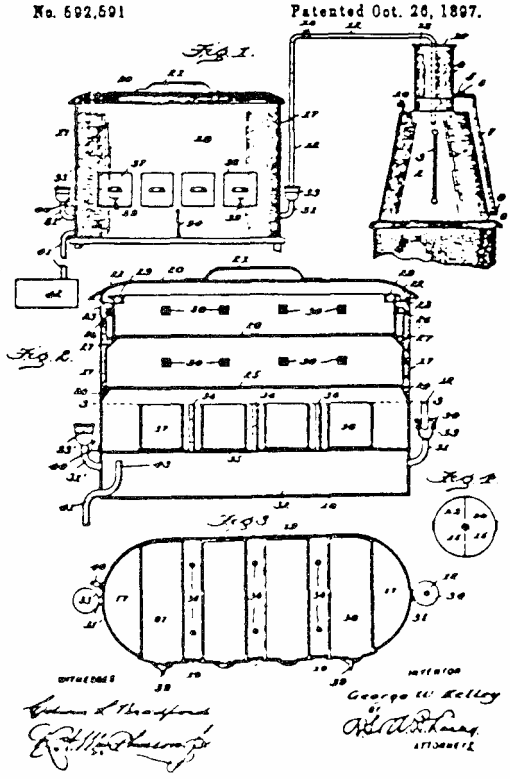
(No Model.)

G. W. KELLEY

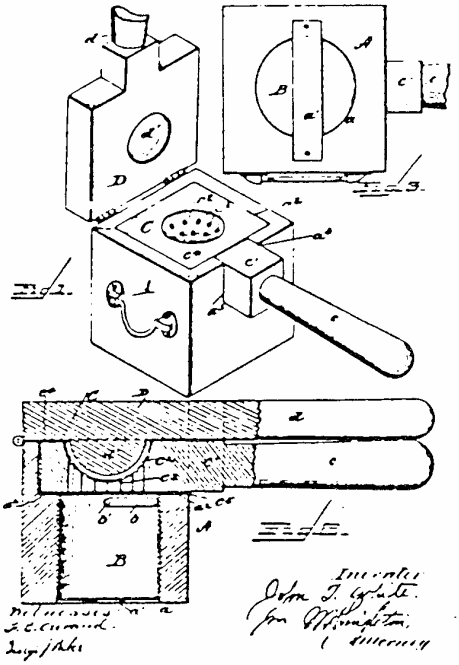
STEAM TABLE.

No. 592,591 Patented Oct. 26, 1897.



8

J. T. WHITE
LEMON SQUEEZER
No. 572,849 Patented Dec. 8, 1896



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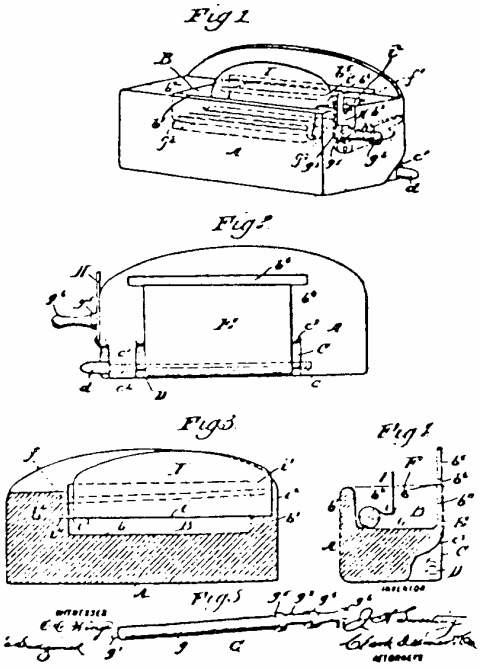
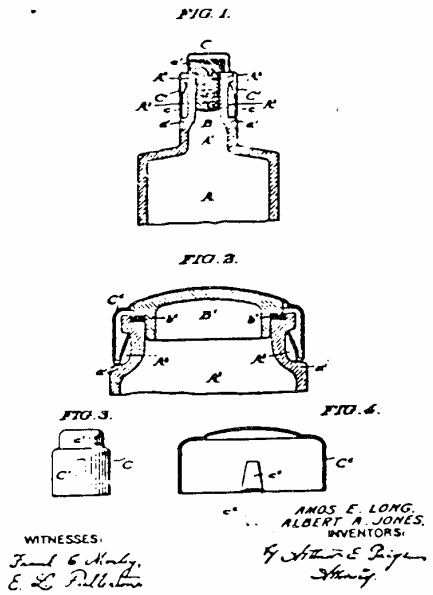
J. A. SWEETING.
DEVICE FOR ROLLING CIGARETTES.
No. 594,601 Patented Nov. 30, 1897.



10

A. E. LONG & A. A. JONES.
CAP FOR BOTTLES, JARS &c.
No. 610,719 Patented Sept. 13, 1898.

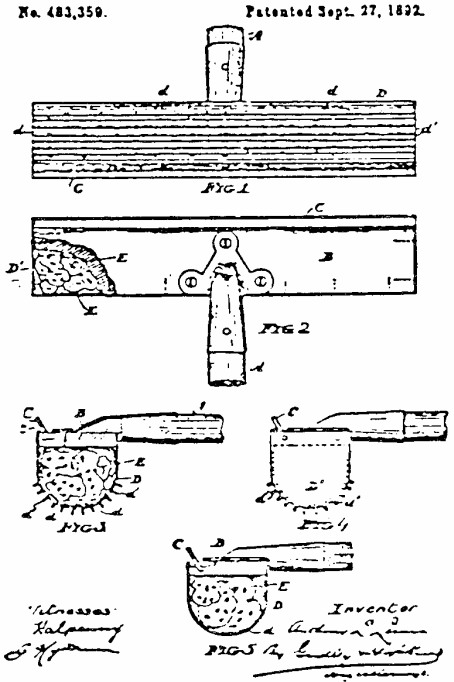


AMOS E. LONG,
ALBERT A. JONES,
INVENTORS.

WITNESSES:

11

A. L. LEWIS.
WINDOW CLEANER.
No. 483,359. Patented Sept. 27, 1892.



Witnesses:

Inventor

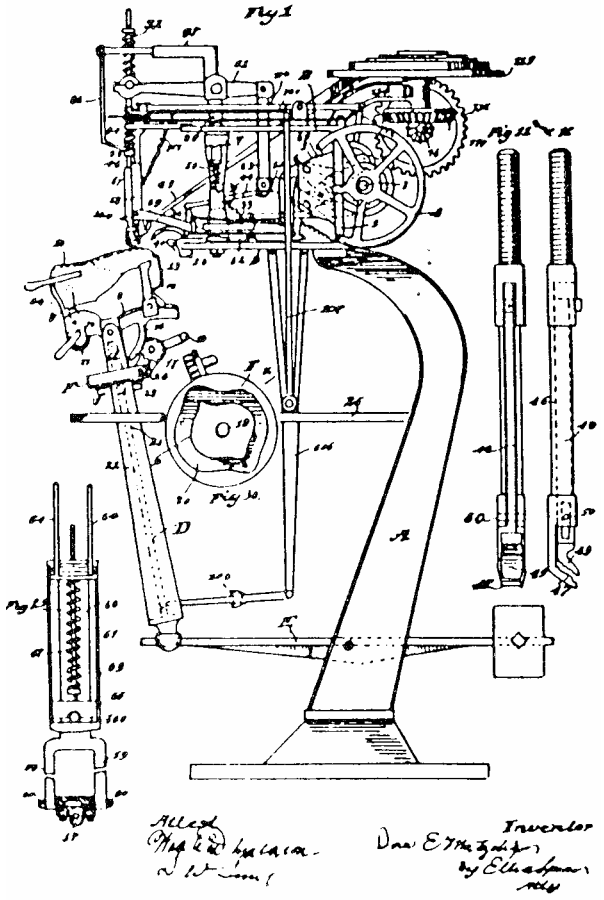
12

(No Model.) 1 Sheets—Sheet 1.

J. E. MATZELIGER.

LASTING MACHINE.

No. 274,207. Patented Mar. 20, 1883.



Witnesses: Inventor

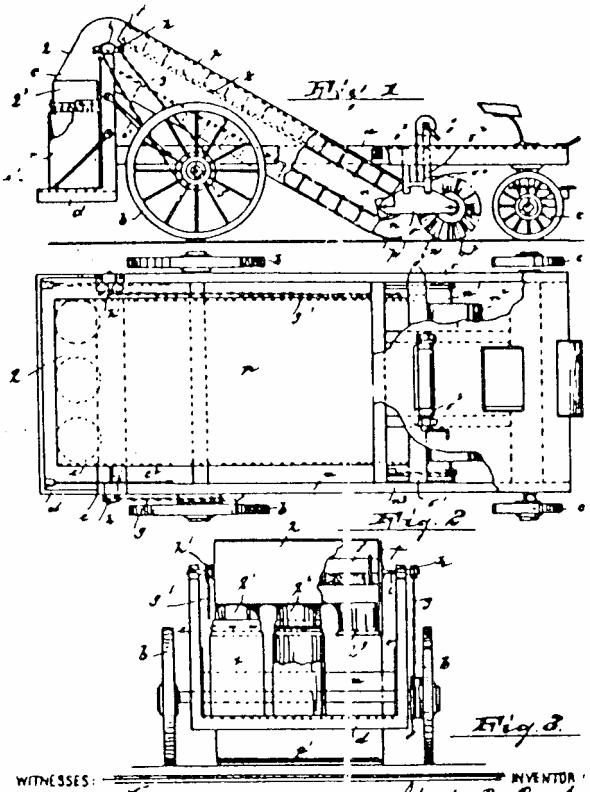
13

(No Model.) 2 Sheets—Sheet 1.

C. B. BROOKS.

STREET SWEEPER.

No. 556,711 Patented Mar. 17, 1896.



WITNESSES: INVENTOR

ATTORNEYS

14

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W. H. RICHARDSON.

CHILD'S CARRIAGE.

No. 405,699. Patented June 18, 1889.

Fig 1.

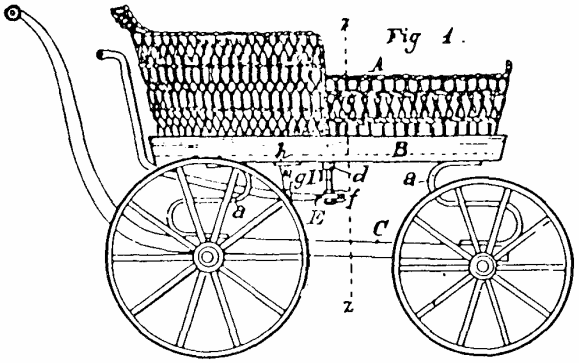
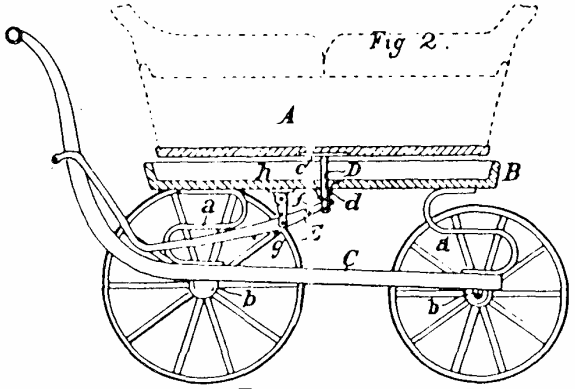


Fig 2.



WITNESSES -

David Fisher

Geo. E. Taylor

- INVENTOR -

William H. Richardson

by Wm. H. Edwards

Atty.

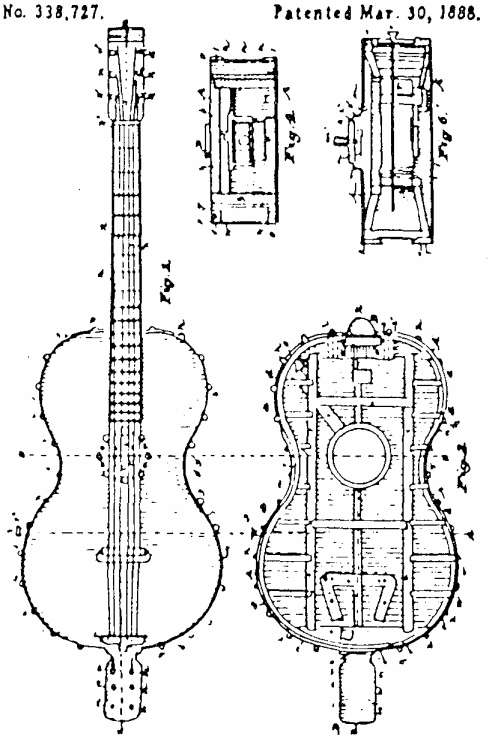
15

(No Model.) 2 Sheets—Sheet 1.

R. F. FLEMMINGS, Jr.

GUITAR.

No. 338,727. Patented Mar. 30, 1888.



Witnesses

Walter E. Lombard

Frank B. Perry

Inventor

Robert F. Flemmings, Jr.

by N. B. Lombard

Attorney

16

No. 638,798. Patented Dec. 26, 1899.

J. M. CERTAIN.

PARCEL CARRIER FOR BICYCLES

(No Model.)

Fig. 1.

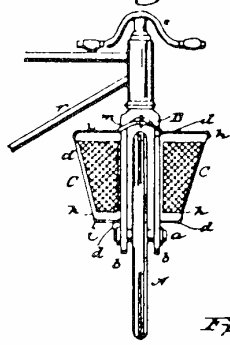


Fig. 2.

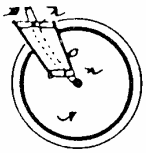


Fig. 3.

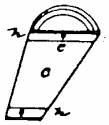
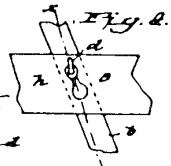


Fig. 4.



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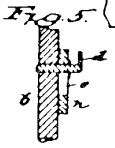


Fig. 6.

Fig. 7.

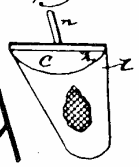
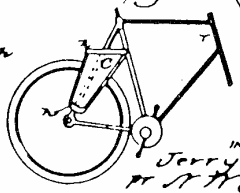


Fig. 8.



WITNESSES:

INVENTOR

Jerry M. Certain

17

No. 634,823. Patented Oct. 10, 1899.

I. R. JOHNSON.

BICYCLE FRAME.

(No Model.)

Fig. 1.

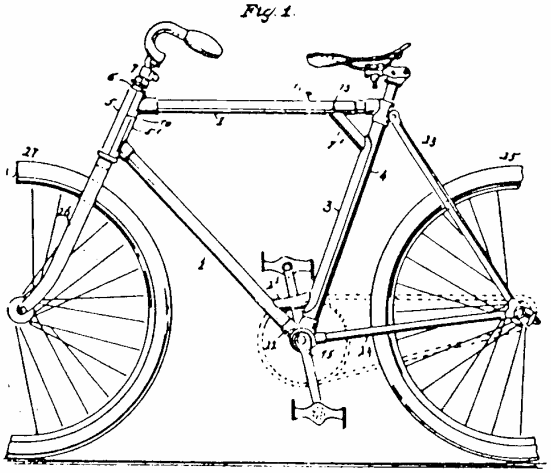
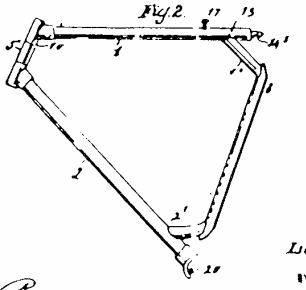


Fig. 2.



WITNESSES:

INVENTOR

Isaac R. Johnson.

BY

ATTORNEYS

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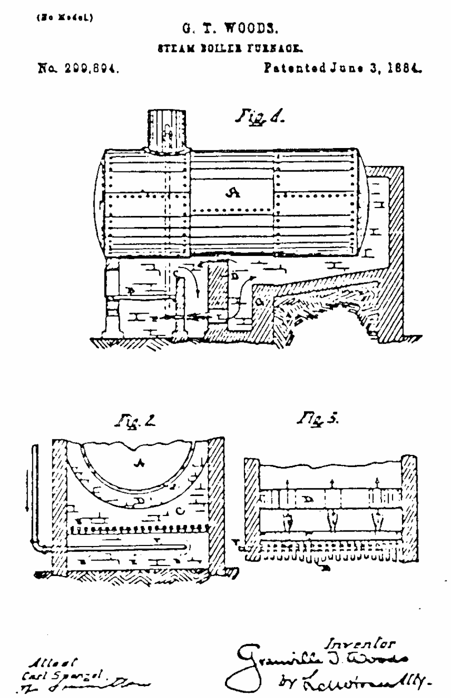
(No Model.)
G. T. WOODS.
STEAM BOILER FURNACE.
No. 299,894.
Patented June 3, 1884.
Fig. 4.
Fig. 2
Fig. 5.
Inventor

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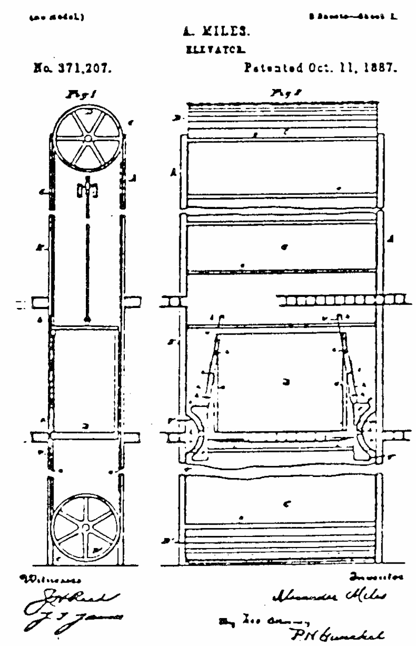
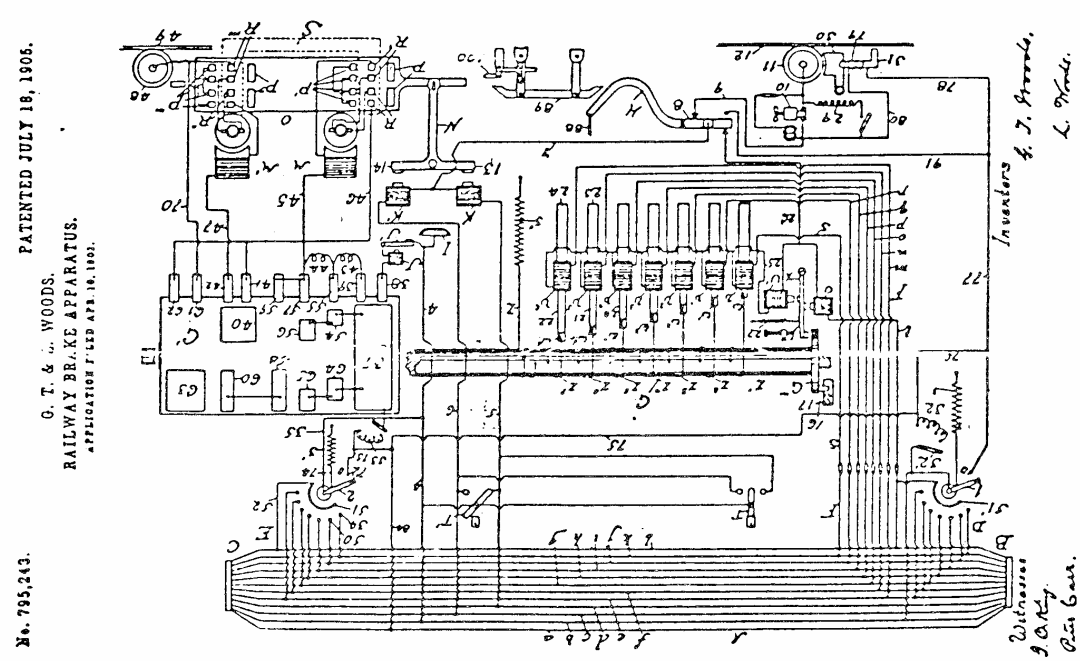

A. MILES.
ELEVATOR.
No. 371,207.
Patented Oct. 11, 1887.
Witnesses
Inventor

18


No. 795,243.
G. T. & L. WOODS.
RAILWAY BRAKE APPARATUS.
PATENTED JULY 18, 1905.
Inventors
Witnesses

21

July 12, 1949. F. M. JONES 2,475,841

AIR CONDITIONING UNIT

Filed June 15, 1944 3 Sheets-Sheet 1

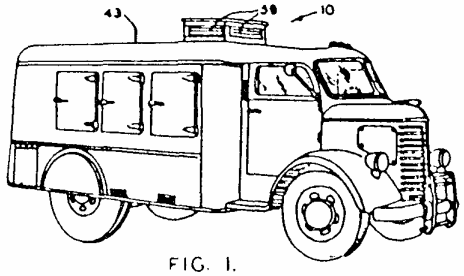


FIG. 1.

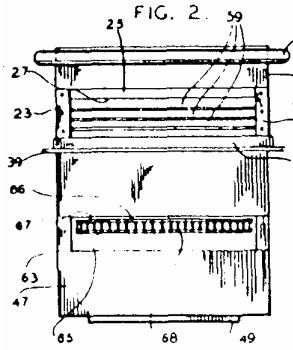


FIG. 2.

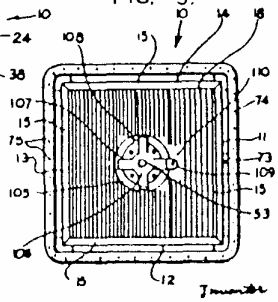


FIG. 3.

FREDERICK M. JONES

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(No Model.) Sheet 1

J. STANARD.

REFRIGERATOR.

No. 455,891. Patented July 14, 1891.

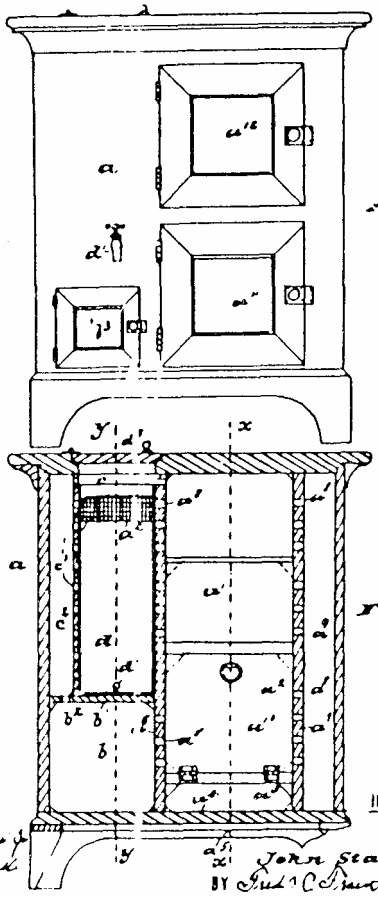


Fig. 1

Fig. 2

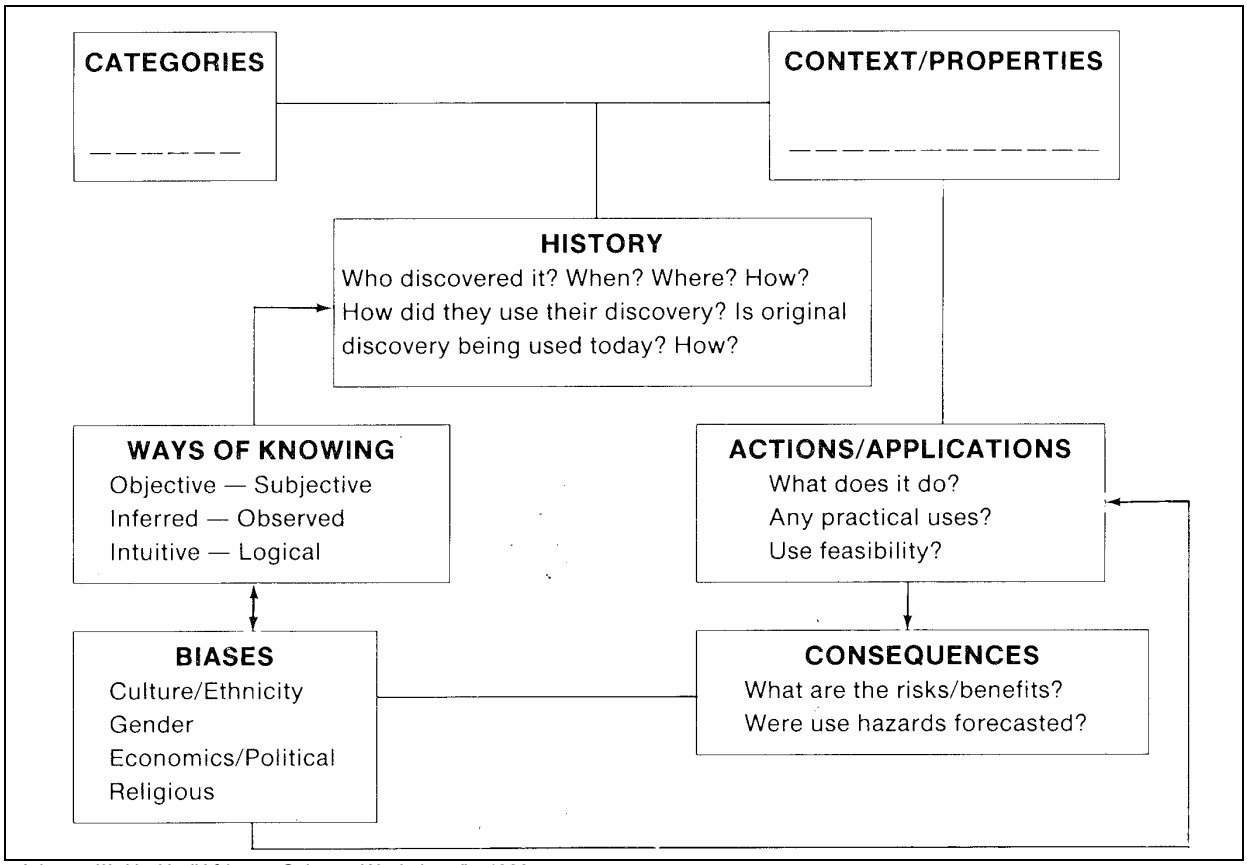
WITNESSES

INVENTOR:

John Stanard

BY Fred'k C. Dwight ATT'Y.

APPENDIX C
MULTICULTURAL SCIENCE LESSON PLAN OUTLINE



Adams, III, H., H., "Africana Science Workshop," - 1986

The Multicultural Science Lesson Plan Outline is designed to be a user friendly aid to help teachers more effectively and easily employ the material of the science essay in their classroom activities. To use, simply photocopy top section, choose "Category and Context/Properties" from **Science Scope and Sequence** and have students answer questions in other boxes as an essay or for classroom discussion. As an added benefit, the outline can help sensitize students to many science, technology and society issues, further aiding their development of critical thinking skills. For example, students can learn to identify a scientist's possible biases and how they may alter one's perception of the degree or seriousness of some technology's risks, or over-emphasize a technology's benefits to serve or protect some special interest group, or they may learn new ways to apply the discovery or technology to foster or enhance social, ecological, ethical or moral harmony and integrity.

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