Egypt as a Field for Anthropological Research.¹

By Prof. P. E. NEWBERRY, M.A., O.B.E.

IT has often been stated that civilisation in Egypt spread from the south, and considerable stress has been laid upon the fact that many pre-dynastic and early dynastic remains have been found in Upper Egypt in the region between Edfu and Thinis, especially at Hierakonpolis and Naqada, and north of Naqada, in the neighbourhood of Abydos. Opposite Edfu is a desert route leading to the Red Sea; at Kûft, opposite Naqada, is the beginning of the road leading to Kosêr, the port on the Red Sea. It has been thought that the people who brought culture to Egypt reached the Nile Valley by one or by both these routes from a "God's Land" situated somewhere down the Red Sea coast. But throughout the whole history of Egypt, culture has always come from the north, and spread southwards.

From a study of the monuments of the First Dynasty that had been found at Abydos and elsewhere in Upper Egypt I ventured, nearly twenty years ago, to suggest the existence in pre-dynastic times of a Delta civilisation which, in culture, was far advanced beyond that of Upper Egypt, and I pointed out that it was probably to a Delta civilisation that the Dynastic Egyptians owed their system of writing. I was led to this conclusion by the following facts. Although many pre-dynastic cemeteries had been thoroughly explored in Upper Egypt, no grave had yielded a single fragment of hieroglyphic writing. The only inference that can be drawn from this is that hieroglyphic writing was unknown, or at all events unpractised, by the inhabitants of Upper Egypt before Dynastic times. On the other hand, the discoveries at Naqada, Hierakonpolis, and Abydos had shown us that all the essential features of the Egyptian system of writing were fully developed at the beginning of the First Dynasty. Hieroglyphic signs were already in full use as simple phonograms, and their employment as phonetic complements was well established. Determinative signs are found beginning to appear in these early writings, but, as Erman and Griffith have noticed, even as late as the Fifth Dynasty their use was very restricted in the monumental inscriptions, although they were common in the cursive and freely written texts of the pyramids. At the very beginning of the First Dynasty the numerical system was complete up to millions, and the Egyptians had already worked out a solar year of 365 days. This was indeed a remarkable achievement.

These facts are of great significance, for it is clear that the hieroglyphic system of writing, as we find it at the beginning of the First Dynasty, must have been the growth of many antecedent ages, and yet no trace of the early stages of its evolution have been found on Upper Egyptian soil. There is no clear evidence, however, that the system was borrowed from any country outside Egypt; the fauna and flora of its characters give it every appearance of being indigenous. It is apparent, therefore, that we must seek the cradle of the Egyptian system of hieroglyphic writing elsewhere than in Upper Egypt, and as the fauna and flora of its characters are distinctly Egyptian, the pre-

sumption is that it must be located in the Delta. An important indication as to the original home of Egyptian writing is given by the signs which, in historic times, were used to designate the points of the compass. The sign for "east" was a drop-shaped ingot of metal upon a sacred perch, and this was the cult-object of a clan living in pre-dynastic times in the Eastern Delta. The sign for "west" was an ostrich feather placed in a semicircular stand, and this was the cult-object of the people of the Western Delta. The sign for "south" was a scirpus-reed; this was the cult-object of a clan which dwelt on the east bank of the Nile a little above the modern village of Sharona in Middle Egypt. The country south of the apex of the Delta was known as Ta Shema, "Reed Land." It must, therefore, have been at some point north of the apex of the Delta that the scirpus-reed was first used to designate the south. It must also have been somewhere in the Central Delta that the cult-objects of the peoples of the Eastern and Western Delta were first used to designate east and west.

For the Delta being the early home of writing another fact has to be taken into consideration. Thoth, the Ibis-god, was to the Egyptians the god of writing, and it was to him that they attributed its invention. The principal seat of his worship in historic times was Hermopolis, in Middle Egypt. But Thoth's original habitat was situated in the north-east corner of the Delta, where, in pre-dynastic times, had resided an Ibis clan. The tradition that named Thoth as the god and inventor of writing would, therefore, point Delta-wards. This tradition is significant also in another way. Although we cannot doubt that the Egyptian system of writing was evolved in the Delta, the germs of writing may have come into Egypt from Western Asia *via* this north-east corner of the country. In this connexion it may be pointed out that the hieroglyphic signs for "right" and "left" were the same as those for "west" and "east"; the Egyptians who evolved the hieroglyphic system of writing orientated themselves facing south.

It is remarkable that so little is known about the early history of the Delta. Few excavations have been carried out there, and nothing of pre-dynastic, or early dynastic, times has, so far, been brought to light from the country north of Cairo. We do know, however, that before the arrival of the Falcon-kings from Hierakonpolis in the south, Middle and Lower Egypt had been, probably for many centuries, united under one sceptre, and that before these two parts of the country were united there had been a Delta Kingdom which had had its capital at Sais. The names of some of these early kings are preserved on the Palermo fragment of the famous Annals Tablet, and the list there given would alone be enough to prove how ancient the Delta civilisation must have been. There was certainly nothing comparable with it in Upper Egypt in those far-off days.

What were the physical conditions prevailing in the Delta and in the regions to the east and west of it immediately preceding the arrival of Menes in Lower Egypt? For the eastern side the evidence is exceedingly scanty, but there is one fact which is significant.

¹ From the Presidential Address delivered to Section H (Anthropology) of the British Association at Liverpool on September 17.

The chief god of the eastern nomes of the Delta in the Pyramid Age was Anzety, a pastoral deity who was the prototype of Osiris. He is represented as a man holding in one hand the shepherd's crook, and in the other the goatherd's ladanisterion. There can be little doubt, therefore, that in the Eastern Delta there lived a pastoral people who possessed flocks of sheep and goats, and this is evidence of a certain amount of grass-land. In the Central Delta at the same period there lived a series of clans, among which a Bull Clan was predominant. In historic times in Egypt the ox is often figured roaming in papyrus and reed marshes, and it may be that the Central Delta marshes supported herds of domesticated cattle.

Much more is known about the western side of the Delta at the time of Menes. It formed, I believe, part of what was called Tehenu-land; at all events this name was given to the region immediately to the west of the Canopic branch of the Nile. There can be no doubt that this part of the country was a very fertile and prosperous region in the period immediately preceding the First Dynasty. Its name signifies "Olive-land," and we actually see these trees figured, with the name of the country beside them, on a pre-dynastic Slate Palette; on this Palette, above the trees, are shown oxen, asses, and sheep of the type later known as ser-sheep. It was Menes, the Falcon-king of Upper Egypt, who conquered the people of Tehenu-land. This conquest is recorded on a small ivory cylinder that was found at Hierakonpolis. Another record of the southerner's triumph over these people is preserved on his famous Slate Palette; here the Upper Egyptian king is depicted smiting their chieftain, while on the verso of the same Palette is the scene of a festival at the Great Port, which was perhaps situated near the Canopic branch of the Nile. The mace-head of Menes, which is now in the Ashmolean Museum at Oxford, has a scene carved upon it which shows the king assuming the Red Crown of Sais, and the inscription accompanying it records that he had captured 120,000 prisoners, 400,000 oxen, and 1,422,000 goats. This immense number of oxen and goats is clear evidence that the north-western Delta and the region to the west of it (Tehenu-land) must have included within its boundaries very extensive grass-lands.

The history of this part of the Delta is most obscure. During the period that elapsed from the end of the Third Dynasty to the beginning of the Twenty-third, when Tefnakht appears upon the scene, we have scarcely any information about it. What was happening at Sais and other great cities in the north-west of Egypt during the period from 2900 to 720 B.C.? There is an extraordinary lacuna in our knowledge of this part of the country. The people living there were certainly of Libyan descent, for even so late as the time of Herodotus the inhabitants deemed themselves Libyans, not Egyptians; and the Greek historian says that they did not even speak the Egyptian language. The pre-dynastic people who inhabited the greater part of the Lower Nile Valley were apparently of the same stock as these Libyans. There is a certain class of decorated pottery which has been found in pre-dynastic graves from Gizeh in the north to Kostamneh in the south. On this decorated pottery are figured boats with cult-objects raised on poles. Altogether

some 170 vases of this type are known, and on them are 300 figures of boats with cult-signs. Of these, 124 give the "Harpoon" ensign; 78 the "Mountain" ensign; and 20 the "Crossed Arrows" ensign. These cult-objects all survived into historic times; the "Harpoon" was the cult-object of the people of the Mareotis Lake region; the "Mountain" and "Crossed Arrows" were the cult-objects of the people dwelling on the right bank of the Canopic branch of the Nile. Thus it will be seen that out of 300 boats figured on vases found in graves in the Lower Nile Valley south of Cairo, 222 belong to cults which can be located in the north-western corner of the Delta. At the beginning of the historic period the cult-objects of the people of the north-western Delta included (1) the "Harpoon," (2) the figure-of-eight "Shield with Crossed Arrows," (3) the "Mountain," and probably (4) the "Double Axe," and (5) a "Dove" or "Swallow." With the exception of the "Harpoon" all these cult-objects are also found in Crete, a fact which is significant in view of Sir Arthur Evans's remark to the effect that he considers the possibility of some actual immigration into Crete of the older Egyptian element due to the first Pharaohs. The "Harpoon," it should be noted, is the prototype of the bident, and later, of the trident of the Libyan god Poseidon. Here in this western side of Lower Egypt is an almost wholly unexplored field for the anthropologist.

I have already referred to the pastoral deity Anzety, who, in the Pyramid Age, was chief of the nomes of the Eastern Delta. Among all the nome-gods he is the only one that is figured in human form; he stands erect holding in his right hand the shepherd's crook, and in his left the goatherd's ladanisterion. On his head is a bi-cornate object that is connected with goats. In the Pyramid Texts, Anzety is entitled "Head of the Eastern nomes," and these included the ancient one of the Oxyrrhynchus-fish, where, later, the ram or goat was the chief cult-animal. Neither the domesticated sheep nor the goat can be reckoned as Egyptian in origin; they both came into Egypt from Western Asia. We have, therefore, in this pastoral deity Anzety evidence of immigration from the west.

Among the cult-objects of the cities over which the god Anzety presided were two which, I believe, can definitely be referred to trees that were not indigenous to the soil of Egypt but to Syria. One of these cult-objects is the so-called Ded-column. This was one of the holiest symbols of the Egyptian religion. It has four cross-bars at the top like superposed capitals. Sometimes a pair of human eyes are shown upon it, and the pillar is draped: sometimes a human form is given to it by carving a grotesque face on it, robing the lower part, crowning the top with ram's horns, and adding two arms, the hands holding the crook and ladanisterion. Frazer has suggested that this object might very well be a conventional representation of a tree stripped of its leaves. That it was, in fact, a lopped tree is, I believe, certain. In the Pyramid Texts it is said of Osiris, "Thou receivest thy two oars, the one of juniper (*uan*), the other of *sd*-wood, and thou ferriest over the Great Green Sea." The determinative sign of the word *sd* is a tree of precisely the same form as the Ded-column that is figured on early Egyptian monuments, *i.e.* it has a long, thin stem.

This tree-name only occurs in inscriptions of the Pyramid Age, and it is mentioned as a wood that was used for making chairs and various other articles of furniture. In the passage quoted from the Pyramid Texts it is mentioned together with juniper, and the latter was employed in cabinet-making, etc., at all periods of Egyptian history. There is no evidence that juniper ever grew in Egypt, but we have numerous records of the wood being imported from the Lebanon region. The *sd*-tree, as we see from the determinative-sign of the name, had horizontally spreading branches, and was evidently some species of conifer. No conifers, however, are known from Egypt; the *sd*-wood must, therefore, have been of foreign importation. As it is mentioned with juniper, which we know came to Egypt from Syria, it is possible that it came from the same region. Among the trees of the Lebanon there are four that have horizontally spreading branches. These are the cedar (*Cedrus libani*), the Cilician fir, *Pinus laricio*, and the horizontal-branched cypress (*Cupressus sempervirens* var. *horizontalis*).

Much misconception at present exists with regard to the Lebanon Cedar, because the name "cedar" is applied to a large number of woods which are quite distinct from it, and the wood which we generally call cedar (e.g. the cedar of our "cedar" pencils) is not true cedar at all, but Virginian juniper. The wood of *Cedrus libani* is light and spongy, of a reddish-white colour, very apt to shrink and warp badly, by no means durable, and in no sense is it valuable. Sir Joseph Hooker, who visited the Lebanon in 1860, notes that the lower slopes of that mountain region bordering the sea were covered with magnificent forests of pine, juniper, and cypress, "so that there was little inducement for the timber hewers of ancient times to ascend 6000 feet through twenty miles of a rocky mountain valley to obtain cedar wood which had no particular quality to recommend it. The cypress, pine, and tall, fragrant juniper of the Lebanon, with its fine red heart-wood, would have been far more prized on every account than the cedar." The *sd*-tree was, I believe, the horizontal-branched cypress, which is common in the wild state. In the Middle Ages this tree was believed to be the male tree, while the tapering conical-shaped cypress was considered to be the female. This is an interesting fact, because there is some evidence to show that the tapering variety was the symbol of Hathor-Isis, while the horizontal-branched one was the symbol of Osiris.

Not far from the city of Osiris in the Delta was Hebyt, the modern Behbeyt el Hagar. Its sacred name was Neter. The Romans called it Iseum. It was the ancient seat of Isis-worship in Egypt, and the ruins of its temple to that goddess still cover several acres of ground in the neighbourhood. On the analogy of other sacred names of cities the primitive cult-object here was the *ntr*-pole. This was not an axe, as has so often been supposed, but a pole that was wrapped around with a band of coloured cloth, tied with cord half-way up the stem, with the upper part of the band projecting as a flap at top. Dr. Griffith conjectured that it was a fetish, e.g. a bone carefully wound round with cloth, but he noted that "this idea is not as yet supported by any ascertained facts." As a hieroglyph this wrapped-up pole expresses *ntr*, "god," "divine,"

in which sense it is very common from the earliest times; gradually it became determinative of divinity and of the divine names and ideographic of divinity. Another common ideograph of "god" in the Old Kingdom was the Falcon (Horus) upon a perch, and this sign was also employed as a determinative of divinity and of the names of individual gods; it even sometimes occurs as a determinative sign of the *ntr*-pole, e.g. Pyr. Texts, 482. This use of the Falcon indicates that in the early dynasties the influence of the Upper Egyptian Falcon-god (Horus) was paramount.

There is reason, however, for believing that the *ntr*-pole cult had at an earlier period been the predominant one among the writing people of the Delta; this, I think, is shown by the invariable use of the *ntr*-pole sign in the words for priest (*hm-ntr*, god's servant) and temple (*ht-ntr*, god's house). Now, on a label of King Aha of the First Dynasty there is a representation of the temple of Neith of Sais. Here two poles with triangular flags at top are shown on either side of the entrance. Later figures of the same temple show these poles with the rectangular flags precisely as we find in the *ntr*-sign. A figure of the temple of Hershef on the Palermo Stone shows two poles with triangular flags, while a Fourth Dynasty drawing of the same temple shows the same poles with rectangular flags. We see, therefore, that the triangular-flagged pole equals the rectangular-flagged one, and that the *ntr* is really a pole or mast with flag.

Poles of this kind were probably planted before the entrances to most early Egyptian temples, and the great flag-masts set up before the pylons of the great temples of the Eighteenth and later dynasties are obviously survivals of the earlier poles. The height and straightness of these poles prove that they cannot have been produced from any native Egyptian tree; in the Empire, flag-staves were regularly imported from Syria; it is probable, therefore, that in the earlier times they were introduced from the same source. A well-known name for Syria and the east coast of the Red Sea, as well as of Punt, was Ta-ntr, "the land of the *ntr*-pole." This was the region in which the primitive Semitic goddess Astarte was worshipped. In Canaan there was a goddess Ashera whose idol or symbol was the ashera pole. The names of Baal and Ashera are sometimes coupled precisely as those of Baal and Astarte, and many scholars have inferred that Ashera was only another name of the great Semitic goddess Astarte. The ashera-pole was an object of worship, for the prophets put it on the same line with the sacred symbols, such as Baal pillars; the ashera was, therefore, a sacred symbol, the seat of a deity, the mark of a divine presence. In late times these asherim did not exclusively belong to any one deity; they were erected to Baal as well as to Yahw. They were sign-posts set up to mark sacred places, and they were, moreover, draped. They correspond exactly to the *ntr*-poles of Egyptian historic times.

I have noted that these *ntr*-poles were tall and straight. What tree produced them? In Egyptian inscriptions there is often mentioned a tree named *tr.t*. It was occasionally planted in ancient Egyptian gardens, and specimens of it were to be seen in the Temple garden at Heliopolis. The seeds and sawdust were employed in medicine, and its resin was one of

the ingredients of the Kyphi-incense. Chaplets were made of its twigs and leaves. The tree was sacred to Hathor; branches of it were offered by the Egyptian kings to that goddess. In a Saite text it is mentioned with three other trees, pine, yew, and juniper; these are all found in Northern Syria, where they grow together with the cypress; the *tr.t* tree may therefore be the cypress. Evidence has been brought forward to show that the *sd*-tree is the horizontal-branched cypress, which was believed to be a male tree, while the tapering, flame-shaped cypress was believed to be the female tree. The Ded-column was the symbol of Osiris, and at Busiris a festival of raising this column was celebrated. The *tr.t* tree was sacred to Hathor, who is often identified with Isis, and there was a festival of raising the *tr.t* tree that was celebrated on the nineteenth day of the first month of the winter season. It is not known where this festival was celebrated, but it may well have been at Neter, the seat of the Isis cult near Dedu-Busiris. The two tree-cults point to Northern Syria as the country of their origin.

In the architecture of ancient Egypt two distinct styles can be recognised. One is founded on wattle-and-daub, the other on wood construction. Wattle-and-daub is the natural building material of the Nile Valley and Delta, and the architectural forms derived from it are certainly indigenous. Those styles derived from wood construction, on the other hand, could not have originated in Egypt; they must have arisen in a country where the necessary timber was ready at hand. Egypt produces no coniferous trees and no timber that is at all suitable for building purposes, or indeed for carpenter's work of any description. The wood of the sycamore-fig is very coarse-grained, and no straight planks can be cut from it. The *sünt*-acacia is so hard that it requires to be sawn while it is green; it is very irregular in texture, and on account of the numerous branches of the trunk it is impossible to cut it into boards more than a couple of feet in length. The palaces of the early kings of the Delta were built of coniferous wood hung with tapestry-woven mats. The tomb of Menes' queen, Neith-hotep, at Naqada, was built of brick in imitation of one of these timber-constructed palaces, and smaller tombs of the same kind are known from the Second and Third Dynasties, but not later. As early as the reign of King Den (First Dynasty) the palaces of this type were beginning to be built of the native wattle-and-daub in combination with wood, and by the end of the Pyramid Age the style disappears entirely, though the memory of it was preserved in the false-doors of the tombs and stelæ. Brick buildings similar to those of the "palace" style of Egypt are also known from early Babylonia, and they were at one time regarded as peculiarly characteristic of Sumerian architecture. These, obviously, must have been copied, like the Egyptian, from earlier timber forms. In Babylonia, as in Egypt, timber was scarce, and there are records that it was sometimes obtained from the coast of Syria. This was the region from which the Egyptians throughout historic times obtained their main supplies of wood, so it is not improbable that they, as well as the Sumerians, derived this particular style of architecture from Northern Syria. I may observe in passing that in this "palace" style we have the transition form

between the nomad's tent and the permanent building of a settled people.

The lack of native timber in Egypt is significant in another direction. Boats of considerable size are figured on many pre-dynastic monuments. They are long and narrow, and in the middle there is usually figured a reed or wicker-work cabin. In my view these boats were built, like many of those of later periods in Egypt, of bundles of papyrus reeds bound together with cord; they were, in fact, great canoes, and, of course, were only for river traffic. They were not sailing boats, but were propelled by means of oars. No mast is ever figured with them, but they generally have a short pole amidships which is surmounted by a cult-object. On one pre-dynastic vase there is a figure of a sailing ship, but this is totally different in build from the canoes, and it has a very high bow and stern with its mast set far forward in the hull. Similar vessels are figured on the ivory knife-handle of pre-dynastic date from Gebel el Araq, but these vessels appear to be in port and the sails are evidently lowered.

I have already referred to the Great Port mentioned on the Palette of Menes. A port implies shipping and trade relations with people dwelling along the coast or across the sea. It may be that the people of the north-western Delta built wooden ships, but if they did they must have procured their timber from some foreign source. Coniferous wood was already being imported into the Nile Valley at the beginning of the First Dynasty from the Lebanon region, and it must be remembered that the Egyptian name for a sea-going ship was *kbnyt*, from *Keben*, "Byblos," the port of the Lebanon, where these ships must have been built and from whence they sailed. The sacred barks of the principal gods of Egypt in historic times were invariably built of coniferous wood from the Lebanon. Transport ships on the Nile were sometimes built of the native *sünt*-wood, and Herodotus describes them as made of planks about two cubits long which were put together "brick-fashion." No masts or sail-yards, however, could possibly be cut from any native Egyptian tree. In the Sûdan at the present day masts are sometimes made by splicing together a number of small pieces of *sünt* and binding them with ox-hide, but such masts are extremely liable to start in any gale, and they would be useless for sea-going ships. It may be doubted whether the art of building sea-going ships originated in Egypt.

It may be doubted also whether the custom of burying the dead in wooden coffins originated in Egypt. In countries where a tree is a rarity a plank for a coffin is generally unknown. In the Admonitions of an Egyptian Sage written some time before 2000 B.C., at a period when there was internal strife in Egypt, the Sage laments that "Men do not sail northwards to [Byb]-los to-day. What shall we do for coniferous trees for our mummies, with the produce of which priests are buried, and with the oil of which [chiefs] are embalmed as far as Keftiu? They come no more." This ancient Sage raises another anthropological question when he refers to the oil used for embalming. The only oils produced by native trees or shrubs in Egypt were olive oil, ben oil from the moringa, and castor oil from the castor-oil plant. The resins and oils used for embalming were principally

those derived from pines and other coniferous trees. Egypt produced no kinds of incense trees or shrubs. The common incenses were pine resin, ladanum, and myrrh, and all these were imported. It is difficult to believe that the ceremonial use of incense arose in Egypt.

These are a few of the questions raised by a study of the material relating to the origins of the ancient civilisation of Egypt. An immense vista has been opened out before our eyes by the discoveries of the last thirty years, and now, in Egypt better than in any other country in the world, we can see man passing

from the primitive hunter to the pastoral nomad, from the pastoral nomad to the agriculturist, and then on to the civilised life which begins with the art of writing. We can see in the Delta and in the Lower Nile Valley tribes becoming permanently settled in fixed abodes around primitive cult-centres, and then uniting with others into one community. We can trace the fusion of several communities into single States, and then, later, the uniting of States under a supreme sovereign. What other country in the world preserves such a record of its early history?

Rare Gas Discharge Lamps.

By J. W. RYDE, Research Laboratories of the General Electric Company, Ltd., Wembley.

A DISCHARGE of electricity through a gas at atmospheric pressure generally takes the form of a luminous spark which will pass only under a potential gradient of several thousand volts per centimetre. If, however, the pressure of the gas is reduced, the appearance of the discharge changes. First it spreads out into wavy streamers; the streamers then broaden until the discharge tube is filled with a diffuse luminous glow extending from the positive electrode to within a short distance of the cathode. This glow is known as the positive column. The cathode is now covered with a layer of bright luminosity called the negative glow, and on close inspection is seen to be not quite in contact with the electrode but separated from it by a thin and sharply defined region, known as the Crookes's dark space. Another less well-defined dark region, the Faraday dark space, is between the negative glow and the positive column. Further reduction of the pressure results in a widening of both dark spaces and the negative glow, the positive column at the same time becoming correspondingly shorter. At still lower pressures the Crookes's dark space increases until finally it fills the whole tube and there is no further luminosity of the gas.

The potential necessary to start the discharge depends on the pressure and nature of the gas, the form and material of which the electrodes are made, and also on the distance between them. In a given gas with given electrodes the starting potential is large at high pressures, but decreases, in an almost linear relation, with decrease of pressure, reaching a minimum at what is called the critical pressure, after which it rises again very rapidly. The pressure at which the minimum occurs depends on the form of the electrodes, their distance apart and the nature of the gas, but the minimum itself depends on the nature of the gas and the material and form of the cathode employed. It is about 200 volts for neon, 280 volts for hydrogen, 340 volts for air, and 420 volts for carbon dioxide. Small traces of impurity affect these values to a great extent; thus, the addition of only 0.5 per cent of pure hydrogen to neon reduces the minimum starting potential by nearly 50 volts, 5.0 per cent reduces it by about 60 volts, but if more than 5.0 per cent is added the hydrogen ceases to act as an impurity and begins to show its own characteristics, so that the starting voltage rises again. On the other hand, small quantities of other gases, such as oxygen, raise the starting potential instead of lowering it. The material of which the

cathode is made has also some effect. The figures given above refer to cathodes of ordinary metals such as iron, nickel, or copper, etc., between which there are only small differences, but with magnesium, barium, or the alkali metals the starting voltage is considerably reduced; in fact, with certain alloys of these metals, the glow discharge can be started in neon at a potential, so low as 90 volts and may be maintained at 58 volts.

When once the discharge has started, the potential can be lowered somewhat before the discharge stops.

FIG. 1.

The curve connecting this "going out" voltage and the pressure is roughly similar to the starting voltage curve, but is displaced to a position somewhat below it on the voltage ordinate.

If the electrodes are only a short distance apart, so that the positive column is absent, the relation between the current flowing and the potential applied across the electrodes is that shown in Fig. 1. The states represented by the lower and upper parts of the curve are unstable, and can be observed only if there is in series with the discharge an appropriate resistance, by means of which the current may be varied. With this arrangement, when the current is only of the order of a micro-ampere, a faint glow is seen some distance from the cathode. The potential between the electrodes falls rapidly as the current is increased, and at the same time the glow becomes brighter and assumes the form of a sharply defined patch moving nearer and nearer to the cathode as the current rises. The voltage now remains sensibly constant, being that known as the normal cathode fall, which is the lowest potential at which