NOTES ON THE OPENING OF THE "BRONZE" SCROLLS FROM QUMRAN[1]

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THE present story of the two "Bronze" scrolls from the Dead Sea concerns the study of their condition, their opening and physical examination, and the preparation of a transcription.

The work just completed has made it possible for the team of scholars in Jordan to begin their labours on the translation and study of the text, and their report is awaited with great interest. A copy of the first official statement can now be added as an appendix to these notes.

Scrolls No. 1 and 2 appear originally to have formed a single plaque of soft copper-base metal, about 8 feet long and 11 inches wide, built from three pieces of the same size riveted together at the ends, the thickness of the metal being three or four times that of a post card (0.03 in.-0.04 in.). The surface has been lettered by means of a punch while the sheet was lying upon a relatively soft base—such as wood—so that the back of the sheet was raised by about its own thickness.

Later an attempt had been made—either in haste or by unskilled hands—to roll the plaque, starting at one end, after the manner of the leather scrolls, and with the inscription facing inwards—but, the varying stiffness of the hammered metal adding to the difficulties, a poor start had been followed by only moderate success and at one joint in the plaque the rivets had failed. The remainder of the plaque, consisting of a single sheet, had then been formed into a second scroll, starting at the opposite end, both sides of the broken joint being visible on the outsides of the scrolls.

The two scrolls, resting one upon the other, were discovered imbedded in the dust of the floor of Cave 3 at Qumran, in the

[1] A lecture delivered in the John Rylands Library on Thursday, the 1st of March, 1956.

year 1952, probably some 2,000 years after their rolling. They presented a tantalizing problem to the archaeologist and the historian. Though obviously much changed, here was a record, apparently intact, which might well have involved the use of over 2,000 letters. Both religious and domestic records of great interest had been found among the leather scrolls—what was this document which had warranted the use of such an unusual method of recording? If used as an ornamental wall plaque, one would expect nail holes to be visible along one edge at least, yet none could be seen; if a library record—surely those with experience and skill to form and work such sheets would have realized the impracticability of frequently rolling and unrolling a sheet having such wide variations of stiffness and hardness as would result from the embossing and work hardening effects of the method of writing employed? Why should the rolling itself show so many signs of lack of skill or of great haste? Only the scrolls themselves held the answer, yet there they lay, corroded, cracked, charged with dirt, far more brittle than glass, tending to disintegrate at the touch, and verily folding their secrets to their hearts. To have attempted to unroll them would have led to complete crumbling. To reconvert the fragile products of decomposition to copper in the form of the original sheet by any means employing heat seemed—at any rate to the writer—to be utterly impracticable, while the form and composition of the remaining material would rule out electrolytic methods. The range of by-products, the contamination by foreign matter, the obvious adhesions and bondings, the extremely complex forms and dispositions involved, seemed to present a quite impossible barrier to success by any such methods.

The remaining possibility seemed to be to detach the material piece by piece, and it was at this stage that the writer, by a coincidence as strange as that of the wandering goat which led to the discovery of Cave No. 1, came to be asked first for advice and then for help.

In the following notes the story of the scrolls will be given in a factual rather than a sequential order.

It was entirely through a chance conversation in a local train that the writer was asked, as an engineer, if it was possible to

cut pieces from old and brittle bronze, and gave his opinion that the cutting itself should present no special difficulty if fragmentation were prevented by the application to the exposed surfaces of one of the modern adhesives, which should form a tough and resilient backing having considerable powers of penetrating the interstices of the corroded material. A few weeks later even the theory of probability seemed to fade when the Director of Antiquities from Jordan placed the scroll upon his desk in Manchester.

A careful examination of broken fragments of the scroll both under the microscope and by metallurgical methods, shows that though the original metal was copper with about 1 per cent. of tin—presumably a naturally impure copper—the material has undergone a complete change. A freshly broken surface shows a highly crystalline mass of a brilliantly red colour (cuprous oxide) and conveys the impression that inter-crystalline corrosion of the base metal has occurred at an early stage though the material is still compact and hard. Some samples examined show no trace of metallic copper at all, though very small quantities were seen in one fragment. Numerous brown bands lying parallel to the surface represent slag-inclusions, like those in wrought iron, formed during the forging process, and these in some places have produced a markedly foliated structure, with occasional breaking of the surface.

A distinctive film of a dark brown colour covers what is now the base material, and is in turn covered with a strongly adhering layer of some highly crystalline substance which is a yellow-green shade—mainly copper oxychloride and silica, with some calcium carbonate in the crevices. Where this layer is fairly thick the outer portions tend to be in the form of a powder which can be removed by the use of a stiff brush. The same product is also present below foliations which have broken the surface and which have therefore been subject to attack from both sides. Where two surfaces have been in close contact the material has formed a bond, making separation difficult, and a number of small pieces had already been detached from their positions and become bonded to an adjacent sheet before opening was commenced. In most cases the area of bonding

was confined to the crests of the embossing on the back of the sheets, but in a few cases intense bonding has had to be overcome over fairly large areas, and in these regions the body material seems to have deteriorated far more than in places free from contact. A thick layer of relatively soft material of an intense blue-green colour was found in a number of places on the larger scroll, sometimes overlaying pockets of a crisp black substance resembling charcoal.[1]

The extremely fine compacted powder of stone-dust which completely filled the interstices of the scroll could usually, when accessible, be removed by brushing, but in some places, apparently in the presence of moisture, had formed an intensely hard stony layer which instantly blunted a steel tool and could only be removed by grinding or by prising the separate grains apart. In some places this matter formed a rough layer intensely bonded to the body material of the scrolls and sometimes locked areas of contact; at others it had the appearance of loosely attached stone droplets, or of a stalactitic incrustation covering thick layers of the green matter.

The thickness and mechanical strength of the scroll material varied considerably, generally being adequate to permit very careful handling, but there were many cracks running round and across the scrolls. In other places, notably in the region where the larger scroll already showed very marked damage, the material was intensely fragile, breaking into tiny fragments at the slightest touch, and very much care was needed to identify and replace them. Looking back at the now completed task and at the remaining tiny pile of unidentified pieces—nearly all devoid of any signs of lettering—one can only be deeply thankful that the original damage has been so very little augmented by the process of opening and cleaning. The general appearance of Scroll 2 is shown in Plate 1.

To allow free manipulation of the scroll without direct handling, it was decided to mount it upon an axle running approximately through its centre. It was found that a light tube of aluminium, $\frac{5}{16}$ in. diameter with a serrated end, or a

[1] The writer is indebted to Dr. N. P. Inglis of Messrs. I.C.I., Metals Division, for the analysis of the material.

stiff wire, would readily serve to remove the packed dust at the core. In the case of the simpler scroll, a little irregular resistance to penetration was offered by a few small stones, and it is possible that the innermost edge of the scroll, which was subsequently found to have been folded very irregularly, was chipped, but no recognizable fragments were seen, and the damaged area proved to be unlettered. A steel axle $\frac{5}{16}$ in. diameter was then held in a vertical position and the scroll lowered over it till the strongest end rested against a rubber-covered flange. Dry dental plaster was rammed gently round the axle, which was thus gripped firmly in the scroll, and plaster was also pressed gently between the convolutions to give full support to the delicate exposed edges. A cap of moistened plaster was applied, both to keep the dry powder in place, and to bed a small wooden disc which served to register a graduated guard disc rather larger in diameter than the scroll. After the scroll diameter had been appreciably reduced the graduated disc could be removed during the process of sawing. The filling and sealing processes were then repeated at the other end, and a second guard ring fitted.

The scroll was thus held rigidly on the axis between two guard-discs, so that it could be laid on a table without fear of damage, and, owing to natural eccentricity, would not roll. At one end of the axle a circular brass clamping plate was added so that, when supported at the ends in a small cradle, any required angular setting could be maintained.

It was obvious that before any attempts were made to cut the scroll the exposed surfaces—which fortunately represented the back of the plaque—should be stiffened and bonded by painting with an appropriate adhesive, after washing the exposed surface with acetone to remove an earlier dressing of cellulose. "Araldite 102", to which has been added 7 per cent. of Araldite hardener 951, and a small quantity of Toluene to assist penetration, has proved so satisfactory that other substances which were made available were not tested. After the application the scroll was warmed to 40°-50° C. for a period in excess of three hours. Except in very few cases this backing prevented the detachment of fragments and enabled the treated pieces to be handled freely and cleaned with complete safety. It was also found that

" Durofix " adhesive, which is not soluble in Toluene, could be used for the attachment of untreated fragments, or for the repairing of cracks, without the risk that the parts would subsequently be loosened on the application of the backing solution.

The treatment with Araldite was repeated as each new surface was exposed and brushed. Any repairs or stiffening with strips of perspex were carried out using Durofix, later reinforced with a second coat of Araldite.

The scroll material could be cut readily by a saw of high speed steel, the cutting edges remaining sufficiently sharp to allow a very light cutting pressure for about three complete cuts. When the stony deposit was touched, however, the edge of the saw was lost immediately. Standard commercial " slitting saws " $1\frac{3}{4}$ in. in diameter and 0.006 in. thick were used and gave an extremely clean cut, removing a negligible amount of material.

In the specially constructed sawing machine shown in Plate 2 the saw revolves at one end of a swinging arm, supported by a spring and pivoted above the scroll, so that the saw, while running, may be raised and lowered by light finger pressure.

The cradle carrying the scroll upon its axle was mounted upon a geometric slide beneath the saw, a knurled extension of one of the slide wheels, twisted gently in the finger and thumb, serving to supply the necessary traverse. The cradle could be offset or swivelled in relation to the saw, thus permitting the scroll to be carefully positioned to ensure the cut being in the best possible position with reference to the embossing and the general form of the piece to be removed.

A complete cut could be made in from $2\frac{1}{2}$ to 10 minutes, using a small fan-blower to clear the sawing dust, and a fixed magnifying glass to give the operator a clear image of the cutting process. In operation it was possible to " feel " at once when the saw had passed through the " metal ", and so prevent damage being done to underlying layers. In all but two cuts a single straight traverse was made.

In general the exact line of cut was chosen to provide the largest pieces which could be lifted clear, and to pass between the letters if possible. Where the cutting of a letter was inevitable this was done at right angles to and near the centre of

PLATE 1.—Scroll No. 2 showing general form, riveted joints, adhesions and an indication of the lettering.

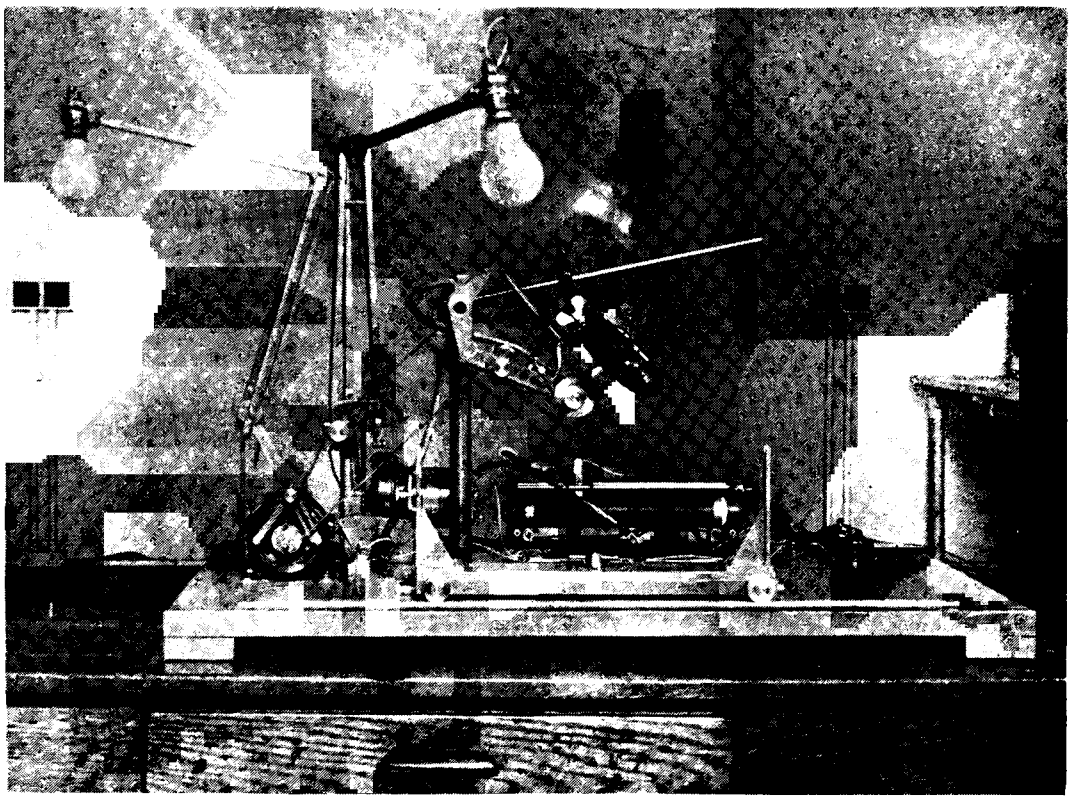

PLATE 2.—The Sawing Machine.

PLATE 3.—Loosening one of the last segments.

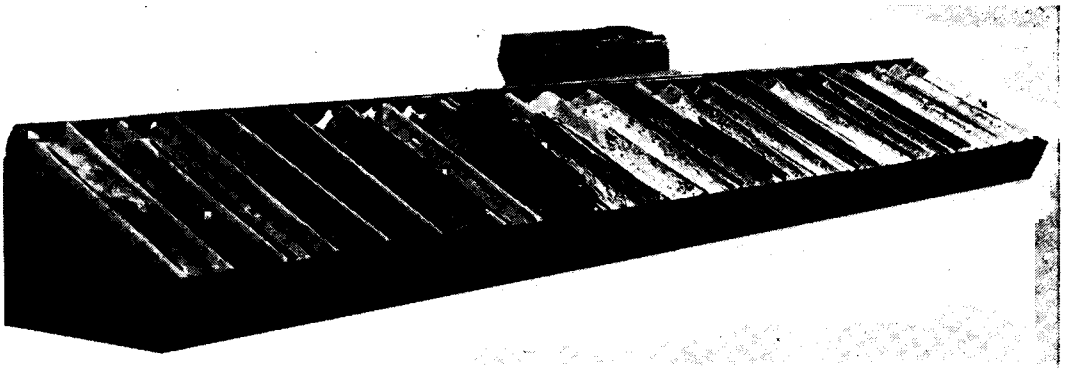

PLATE 4.—The Scroll sections lying in the uncompleted show-case with a scale model of Scroll 2 behind.

the lines cut, so that the form of the complete letter could be traced clearly when the two adjoining segments of scroll were replaced close together. It is believed that no letter has been made unrecognizable by the sawing.

In a number of cases it was found possible to cut the scroll in the unlettered spaces which were found to occur regularly between columns of writing, while in a very few cases the position was determined in relation to suspected lines of adhesion or a sharp fold in the material.

After sawing, the carriage, with the scroll in position, was transferred and clamped to a table by means of a central vertical screw which, in combination with the rotating and clamping arrangements for the axis, enabled the scroll to be placed in any position convenient for the next operation. This consisted of the loosening and removal of the dust beneath the layer to be detached, usually by means of a soft brush or a probe of perspex or sheet tin, as shown in Plate 3.

During this and other dusting operations the very fine mineral dust, which was always accompanied by a considerable proportion of copper salts, was drawn away from the operator by a suction fan discharging into a vacuum cleaner bag, the operator finding the dust highly irritant to nose, eyes and chest.

In many cases the segment could then be lifted at once, and when small adhesions only were present a gentle rocking served to break them down. In the more compact scroll, however, and especially towards the centre where the convolutions were markedly elliptical, the adhesions covered considerable areas, and long and broad adhesions of great strength had been accompanied by almost complete rotting of one of the mating surfaces. Where such conditions were anticipated it was found best to arrange a cut to coincide with the line of bonding, so giving immediate access to the binding material. One such adhesion could only be broken down by removing the upper layer in pieces, but in this case in particular the Araldite coating proved invaluable, and the cleaning and re-assembly of the pieces, though very laborious, was accomplished with only a trifling loss of letters. As far as can be judged after the completion of the work, any other method than that of backing

and sawing would have resulted in reducing the whole of the sheets to little more than powder.

To reduce the significance of accidents, and to assist in the preparation of a transcription, photographic records were made at each stage, first of the outer surface of the original scroll and then of each surface exposed. Photographs of the hollow curved surfaces were made from several directions, each to give a fair reproduction of the lettering on a strip of surface at right angles to the axis of the lens, and from a fixed distance. Considering the very irregular surface conditions, this presented considerable difficulty. Better photographs for certain details could have been obtained, but in view of the very large number of photographs involved and the purpose for which they were intended the results have proved satisfactory. They were not intended for the making of direct readings as an alternative to the transcription to be described.

All photographs of the exterior of the scroll showed the indexing disc from which the angular positions were transferred to the edge of the scroll in white paint, along with a letter corresponding to the convolution. The positions were also marked on paper strips attached to the segments so that the ends projected and were visible on photographs showing the lettered faces of the segments. This indexing proved invaluable when identifying and arranging the many photographs required in the preparation of the transcription.

After lifting a segment the mineral dust could be loosened very readily with a tooth-brush, after which the loose yellow-green dust could be swept off with a nylon dental brush using the standard dental equipment of foot-controlled motor, flexible drive and hand-piece. Except where adhesions, etc., were present, this treatment left a bright green skin, smooth though very far from uniform, with the depressions of the lettering very clear and distinct. Normal decomposition products, when present in greater thickness, could be removed using a dental burr, and burrs rotated at an extremely slow speed were also successful in breaking down the stony matter, the cutting edges entering like wedges between the granules and prising them apart.

Using a very small burr and a powerful magnifying glass it was possible gradually to remove excessive deposits, judging the stage reached from the colour of the dust.

Owing to the method of forming the letters the strokes appeared as valleys between rounded hills, with an appreciable thickness of fairly soft yellow-green deposit in the actual tool mark at the bottom. During the removal of the thicker deposits the hill tops were the first to be disclosed. Passing the burr backwards and forwards at right angles to suspected valleys these were disclosed and deepened without in any way biasing the tool, the sideways travel becoming shorter and shorter till the cutter centred itself in the groove made by the punch and then guided itself easily along the lines of the letter. Towards the last stages the letter form would generally become obvious through a change in colour of the deposit. This technique was valuable as the burr was not given any deliberate guidance as to the whereabouts and direction of the lines, and, very rapidly losing the keenness of its cutting edges, would not touch the copper-coloured base material, though it still easily threw out the softer deposits. The curved surfaces adjacent to the letter lines are characteristic of the method of lettering, and could be used to identify surface irregularities due to lettering from those due to corrosion, cracks and other defects. Except where broken by serious foliation and the interpenetration of secondary corrosion—a fairly common fault—or where disrupted through heavy bonding, it can be claimed that the surface of the base material has been left virtually intact. In a few cases further exploration may possibly reveal other details, but it is doubted whether much has been missed. Certainly almost nothing has been destroyed.

After completion of the work in Manchester the inner faces of the sections were washed with perspex solution to seal the surfaces and prevent further corrosion.

The direct reading of the scroll would be a very tedious matter, partly because the surface is much marked by creases and other irregularities which attracted the eye away from the lettering, partly because of the curvature of the sections which gives differing lighting effects—and also because one line of

script might well extend over two or three segments which would therefore have to be considered in juxtaposition.

Sections of the photographs of the lettering were therefore marked in such a way that the complete inner surface was represented by a series of longitudinal strips selected as showing the lettering to the best advantage. The lettering on each strip was then picked out in white ink and traced, after which the tracings were reversed and projected onto white card using a special epidiascope giving a magnification of about $2\frac{1}{2}$ times, the letters, scroll edging, etc., being copied in pencil.

The pencil script was then compared and corrected in detail with the actual scroll, and independently checked, further cleaning being carried out in places of difficulty. The final pencil draft was then inked and photographed, and it is from these photographs, further checked against the scroll sections if necessary, that the translation is being prepared.

It is very satisfactory to find that of the 3000 symbols used on the plaque only 5 per cent. are missing, and in all cases the loss is due to damage sustained prior to the attempt at opening. Only 2 per cent. of the remaining symbols have been marked as doubtful, and further cleaning may possibly reduce the number.

General Comments on the Scrolls

A number of matters of interest arise from a general examination of the scrolls.

The plaque has only been pierced once in a manner which might have enabled it to be " hung up ", and this is at the edge opposite the centre of the first column of writing, where a hole about $\frac{1}{4}$ in. square is surrounded by an area showing considerable distortion, as though stretched by a taper peg driven from the face. If supported in this way, however, the lines of script would have appeared vertically instead of horizontally. This " peg hole " may have been used to hold the metal onto the scribe's table.

The first turn of the smaller scroll is not only flattened but is bent as by pressure of the thumbs of one attempting the operation in a hurry or having little skill, and the first turn of the larger is sadly elliptical and shows a bad kink where the soft unlettered margin adjoins the stiffer lettered area.

In general the lettering of the scrolls has been clumsily performed. The small straight punch has sometimes been much too long to give the shape of the curves without the appearance of undesirable tangent lines; in many cases the punch has made a number of separate and rather random impressions instead of being allowed to follow and extend an impression already made, and the blows seem to have been of very varying intensity. If a wooden base had been used the presence of knots may have caused irregularities.

Though succeeding rows of letters start in good alignment and are generally of equal length, they have not been carefully laid out, as is characteristic of the lettering on the leather scrolls. Some lines are inclined, and one, starting too high, has been bent sharply downward to prevent interference with symbols in the line above.

Many of the letters are slightly incomplete, others are set at a random angle. When the scribe has found himself running short of space towards the foot of a column, he has crowded the letters and reduced their size, and as he started the last column, the possible shortage of writing surface seems to have " got on his nerves " and he appears to have overcrowded the lettering only to find that in the end he had about one-third of a column to spare. The sizes of the letters vary within the range of 5 : 1. A few additions have been made, presumably to correct spelling mistakes.

Until the scholars have completed the task now laid open to them, speculation about the scrolls would be very largely futile, and we must await their report with patience. The scrolls still hold their mystery, but at last there is good hope that it may be solved.

Plate 4 shows the scroll sections lying in sequence in the frame which, on completion, is to be used for their exhibition in the Museum in Jordan, with a scale model of Scroll No. 2 shown for comparison in the background.

Epilogue

As the draft of the above report was being completed a letter arrived from the Director of Antiquities suggesting that Manchester should release the first news of the contents of the bronze scrolls.

The authorised statement released on 1 June reads as follows :

The inscribed copper rolls from the Dead Sea Caves which were recently opened on behalf of the Jordan Department of Antiquities by the College of Technology, Manchester University, have now been studied and a preliminary translation made by Abbé Milik, working in the Palestine Archaeological Museum, Jerusalem. They contain, most surprisingly, a collection of traditions about the hiding place of ancient treasure, altogether about sixty hoards being described. The treasure consists of gold and silver, measured in talents, boxes of incense and so on, and the area referred to ranges from Hebron to Mount Gerizim near Nablus, though most of them appear to be in the vicinity of Jerusalem. The exact localities are, of course, difficult to identify nowadays, as the topography of the country has changed considerably since the 1st century A.D. The following brief extracts show the nature of the document :

> In the cistern which is below the rampart, on the east side, in a place hollowed out of the rock ; six hundred bars of silver . . .
>
> . . . Close by, below the southern corner of the portico at Zadok's tomb, and underneath the pilaster in the exedras, a vessel of incense in pine wood and a vessel of incense in cassia wood . . .
>
> . . . In the pit nearby towards the north, near the graves, in a hole opening to the north, there is a copy of this book, with explanations, measurements and all details.

It is difficult to understand why the Essenes should be so concerned with stories of hidden treasure, and particularly why they should consider them worth engraving on copper, an expensive metal in those days. Curious, too, is the statement contained in the last paragraph that there is a second copy of this book with explanations, which latter we should very much like to have. One is reminded of the account in Josephus of how Hyrcanus I and Herod the Great opened the tomb of King David and removed treasure from it, and there are similar modern guides to hidden treasure, particularly in Arabic.

The total amount of gold and silver listed amounts to nearly 200 tons, obviously a fantastic figure, and coupled with the depth at which some of the hoards are alleged to lie—16 to 18 feet—makes one doubt the authenticity of the stories. However, it is the first ancient document of its kind—a guide to treasure trove—ever to be found, and it is also the earliest known text in colloquial, Mishnaic Hebrew.

The Jordan Department of Antiquities is greatly indebted to the Principal and Governors of the College of Technology of Manchester University for allowing the opening of these rolls to be done there free of charge, and to Professor Wright Baker for his ingenuity and patience in carrying out the work. Also to the British Council for granting a bursary to our Technical Assistant, Mr. Mohamed Saleh, to work with Professor Wright Baker and study the technique employed.

The present writer would, in turn, express his own thanks and the thanks of those who have worked with him, for the opportunity so unexpectedly provided to play a part in an investigation of such extraordinary interest. Their greetings and best wishes go out to those who are continuing the great work.