THE SILOAM TUNNEL.

JERUSALEM, 1*st December*, 1881.

THE details recorded in the Siloam inscription concerning the great conduit, seemed to render it expedient to revisit the channel, in order to search for the point of junction between the two working parties, as well as to ascertain whether any other inscribed tablets might exist in other parts of the tunnel, or whether any marks connected with original measurements might remain.

Lieutenant Mantell, Mr. Armstrong, and I therefore visited the tunnel on 10th November, and spent nearly five hours in it, crawling from one end to the other, and measuring carefully, with a chain and a prismatic compass, the whole length between the Pool of Siloam and the upper spring (en Rogel, Gihon in the Valley, Bethesda, 'Ain Umm ed Deraj, or the Virgin's Fountain, as it is variously called).

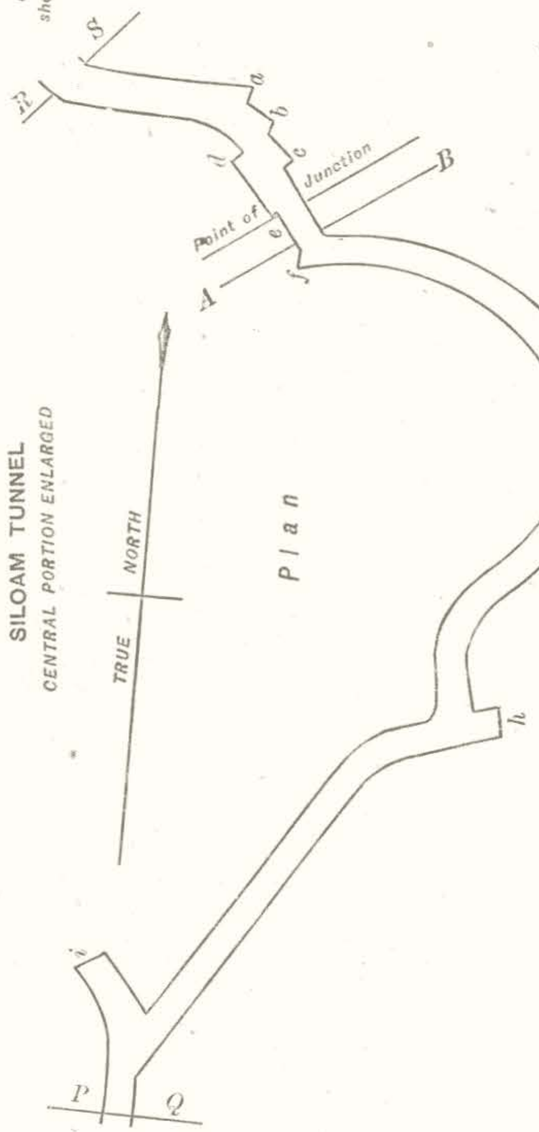
We found less difficulty than Captain Warren experienced, because the level of the water has been lowered, and the overflow of the upper spring does not occur often in autumn. We were nevertheless very anxious while employed in the central section of the tunnel, where the height is only about 19 inches for some 20 yards, the breadth being only about 2 feet: for if the waters were to rise here (when the overflow occurs) to a height of little over a foot, it would be almost impossible to escape drowning. We were unable to ascertain when the water was expected to rise, or the height to which it attains; but fortunately no overflow took place during the five hours which we spent in the tunnel, and we suffered only from the discomforts of mud and leeches and wet clothing, with the fatigue due to crawling so long in a cramped position, occasionally over stones or sharp fragments of broken pottery.

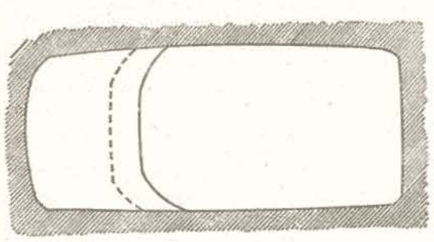
The measurement which we obtained with a chain (afterwards corrected by the standard) gives a total length of 1,706·8 feet between the Siloam end of the tunnel and the place where it enters the cross passage to the Virgin's pool, thus agreeing within 2 feet with Colonel Warren's total of 1,708 feet, and proving that his conjecture as to Robinson's measurement must be correct, and that the latter authority includes in his total of 1,758 feet that portion of the cross passage which leads from the Siloam tunnel to the back of the Virgin's pool, and which measures 50·8 feet by the chain.

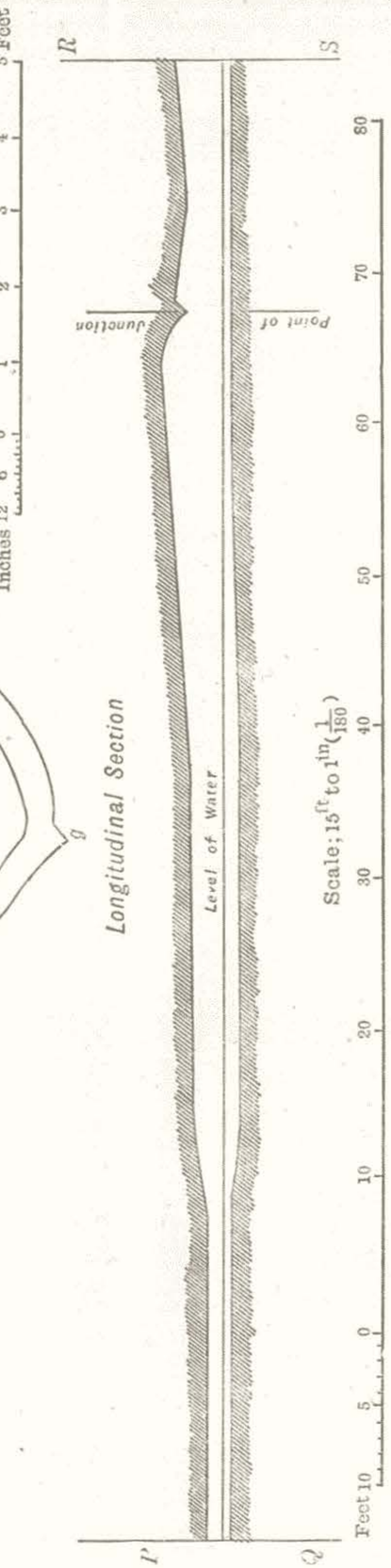
The accompanying plan will be found to agree with that of Colonel Warren. The section is made from measurement of the height of the channel in different places, taken by us at frequent intervals where a marked alteration occurs. The surface is shown in accordance with the intersections along the canal of the contours shown on the Ordnance Survey; and the supposed rock surface agrees with Colonel Warren's "Rock Contours on Ophel," checked in one place by an actual measurement of the rock surface, which we have now taken in the vertical shaft leading up from the roof of the tunnel.

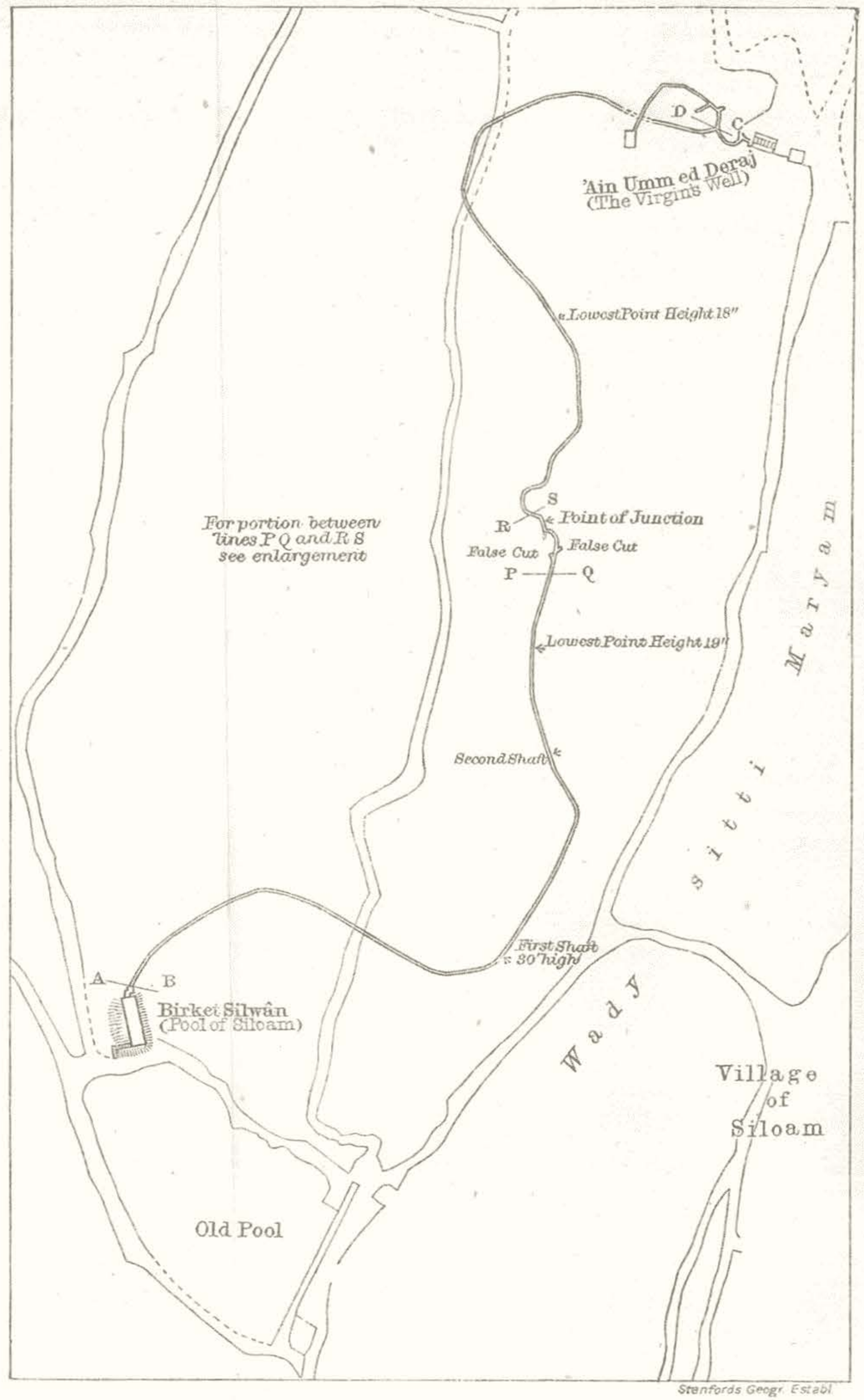
SILOAM TUNNEL

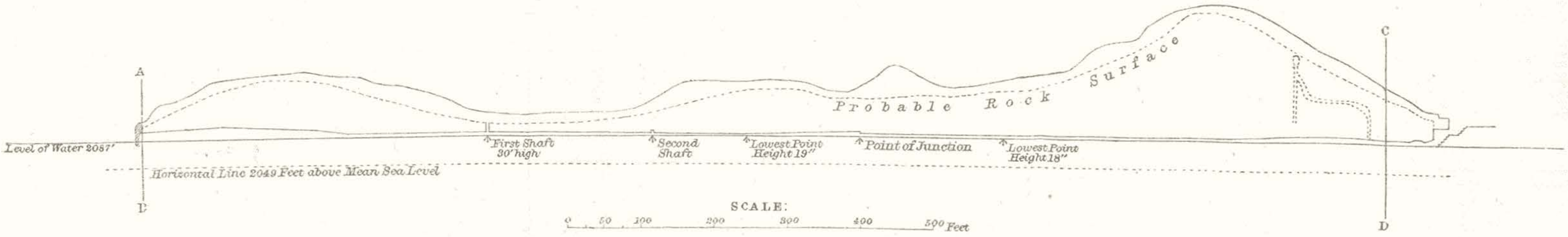
CENTRAL PORTION ENLARGED











We were, however, not completely satisfied with the results of our first visit, and accordingly, on the 22nd November, Lieutenant Mantell and I revisited the tunnel with a view of ascertaining the point of junction between the two working parties, and of searching for measurement marks on the walls.

We entered from the northern end, and had just commenced operations, when a shout from our servant warned us that the waters were rising.

When we first entered there was not much more than a foot depth of water in the pool, but the rush of water was now very rapid, and the depth increased just after we had reached the foot of the steps which lead down to the pool, to 4 feet 7 inches. The sound of the current pouring down the tunnel was distinct, and the depth of water in the channel, as we found afterwards, was somewhat over 9 inches, so that before the level had been lowered at the Siloam end the passage of the tunnel must always have been a very dangerous undertaking; and, indeed, might still prove so to an explorer caught by the overflow in the lowest part of the passage near the centre.

On our second visit we remained four hours in the tunnel, and inspected both walls very carefully, from the northern entrance to the place where we now suppose the junction of the two working parties to have occurred. I think we may state with confidence, that there is no tablet similar to that now famous, to be found in any other part of the tunnel, and that there is no other inscription. There is, indeed, no place fitted like that where the existing tablet has been found, because the tunnel is quite dark except at the mouth, and is for the greater part of its length so low that it would be extremely difficult, and often impossible, to carve an inscription.

As regards the existing tablet, I may remark that I have examined it again very closely, and feel convinced that the inscription has not been in any way damaged by the application of hydrochloric acid to remove the lime deposit which had filled in the letters. I have made the same remark in the previous *Quarterly Statement* (p. 278), but Professor Sayce appears (p. 282) to adopt the opinion of Mr. Pilter, that the acid has damaged the inscription, and he remarks that my report "makes the fact quite plain." We have, however, copies by Dr. Guthe, taken both before and after the cleaning of the inscription, which served to show that no bad effect resulted from the repeated washings; and the rock surface is still quite firm and hard, showing no signs of rottenness or chipping. I cannot but think that the letters which Professor Sayce put down, and which cannot now be discovered on any of the squeezes or casts, were not actually existent in the rock, but were merely marks formed by the lime deposit, and thus removed by the acid. Having seen the tablet before the acid was applied, I can add my testimony to that of others as to the entirely different aspect which the inscription presented before and after cleaning.

Before cleaning it resembled a rude scrawl of uncertain shapes, while it is now seen to have been carved with great care, in regular lines, and with constant forms for every letter. The copy published in the *Quarterly*

Statement for April, p. 70, contrasted with that given in October, p. 286, gives in fact a very fair idea of the difference which was made by cleaning the tablet.

The cast which has now reached England is fortunately so good that but little room for dispute can be left. It appears that the text must originally have consisted of about 190 letters, of which 171 are recoverable. This number exceeds that which was first given in Professor Sayce's copy, the total of which was 169 letters. It seems, therefore, clear that no letters have been lost in the process of cleaning.

The cast and squeeze will be found to agree with Professor Sayce's copy in 151 out of 169 letters. It is therefore clear that, practically, Professor Sayce was able, in spite of the great difficulties which he encountered, to transcribe correctly the great bulk of the inscription, and thus was the first to give the reading which in the main has been accepted. In his latest copy he has corrected 13 letters out of 18, in which he differed from the squeeze and the cast, and has added one of the two missing letters. The points of dispute, so far as the letters are concerned, are thus reduced to five letters which are doubtful, and two letters which appear on the cast but were not sent home on the squeeze, or noticed in the accompanying report.

I have also compared the cast and my own squeeze with Dr. Guthe's copy, which is the best which has been made, with exception of the cast. Dr. Guthe's copy agrees with ours in every respect. He has, however, shown six more letters than we were able to recover, and all six are correct according to the cast. Indeed, Dr. Guthe's copy appears to be perfect, with exception of the omission of two letters in the first line, which will be discovered on the cast.

The important details which will be elucidated by the cast are as follows :—In the first line Professor Sayce and Professor Socin read הנקבה בעוד. It seems, however, from the cast, that the second word is perhaps בערצו. In the fourth line Professor Sayce reads אל המים, but Professor Socin על המים. It will be seen from the cast that Professor Socin is right. There are, of course many other minor points on which the cast throws much light, confirming the squeeze in a very satisfactory manner. In the fifth line there is no doubt room for the disputed letters in the reading במאתים ואלף, but I have not been able to find any traces of the ם ו on either squeeze, cast, or stone ; and it seems highly probable that a fissure in the rock here existed at the time when the inscription was cut.

The two letters הן at the beginning of the inscription, which Professor Sayce adopted from Mr. Pilter, I have never been able to find on the stone, although the original surface is preserved, nor have I been able to find the letters (ה)ז at the end of the inscription, which are also absent from Dr. Guthe's copy. Possibly these, and the disputed ק in the second line, may have been marks due to the lime incrustation, and not actual letters at all.

I may now proceed to describe the reasons which induce us to suppose that we have been able to fix the exact point of junction of the two working parties, in a position which exactly agrees with the inscription, according to Professor Sayce's latest translation (*Quarterly Statement*, October, 1881, p. 284). For this purpose we have prepared an enlarged plan and section of the central part of the tunnel, where a remarkable S shaped contortion occurs.

At the points *a*, *b*, *c*, *e*, *f*, *g*, *h*, and *i*, certain *set backs* will be observed in the walls of the passage, which indicate a sudden change in direction on the part of the excavator. They are, indeed, false heads, abandoned apparently from the conviction that the passage was not going in the right direction. In the case of *h* and *i*, however, which are out of the general direction, and continued further, these recesses may have served as sidings, allowing two excavators to pass one another, which would be impossible without them.

The important point, however, to observe is that some of these headings point up channel, and some point down, and this not without a system, for while *a*, *b*, *c*, *e*, point down, *g*, *h*, *i* point up. Similar headings occur in other parts of the tunnel, but they always agree with the rule thus observed, those which are between the Virgin's Fountain and the point *a*, pointing down stream, and those between *i* and Siloam pointing up stream.

Each of these headings has a rounded top, such as would result from the excavation of the rock with a pick, by a man working with his face to the front. It shows that on turning aside from the heading he left the roof unfinished, in just the form which would result from the swinging of a pick in a curve, which,—as a moment's reflection will convince the reader,—is the shape natural to an unfinished excavation. Looking at the plan then, we see that an excavator facing *down stream* was working at the headings *a*, *b*, *c*, and was three times induced to work away further to his right. Looking at *f*, we see an excavator working up stream and induced to turn to his right. We see, moreover, that the point *e* might have been the actual point where the channels met, as there is a slight set back down stream within 2 feet of the set back *f*, up-stream.

Now on looking at the section and cross-section, it will be seen that there is a sudden difference of level in the roof of the channel at this point.

Within a distance of 2 feet 6 inches it falls from 4 feet 8 inches to 3 feet 7 inches, and a sort of ruin occurs where the lower channel (up-stream) joins the more lofty down-stream excavation.

In fact, the general appearance of this part of the tunnel, looking up-stream from *f*, is that of a smaller drain opening into a main drain, and would of itself suggest that this is the point of junction, without considering the testimony of the headings. It may, therefore, I think, be considered certain that the place of junction was at the point *e*, or 944 feet from the mouth of the tunnel, and consequently 813·6 feet from the back of the Virgin's Fountain.

This discovery agrees in a remarkable manner with the wording of the

inscription. In the directions which are indicated by the headings at *a* and *f* the two parties were working nearly parallel to one another, and might have passed each other without joining, having a thickness of seven feet of rock between ; those in the up-stream channel being to the right or east of those in the down-stream tunnel. Each, therefore, began to turn to his right ; and those in the up-stream channel did so most rapidly. The shape of the cutting at the point *d* gives evidence of a very complete change of axis. This is not, as might be supposed from the plan, an up-stream heading, conflicting with what has been said before ; for the roof of the tunnel at *d* is curved on the *side* and not at the *end* of this set back, showing that the workman, after leaving the false headings *a*, *b*, *c*, began to widen the channel on his right, facing for a short time to the side instead of to his front. The little buttress thus left was never cleared away, but remains to give its evidence of the method of excavation of the tunnel.

The inscription (line 2) tells us that *three cubits* remained to be broken through, when it was discovered that there was an "excess in the rock to the right." Now if we consider the down-stream party to have worked to *e*, it will be seen that the party at *d* were just three cubits of 16 inches from them, when they discovered their excess, and began to cut away the rock on the right. It was this which was done according to the text (line 3), for they "struck on the west" that is, facing west, just as we have seen the excavator at *d* must have faced. The party at *e*, in the meanwhile, seem to have stopped working, which they would naturally do, to avoid injuring, or being injured by, the others when the pick struck through the last dividing partition of rock. Again, in the last line, we read that "three-fourths [?] of a cubit was the height of the rock over the head of the excavation." If this be the correct reading, it is remarkable that the difference of height of the two channels at the point of junction is just 13 inches or close upon three-fourths of a cubit of 16 inches.

Unfortunately, however, the text is deficient just in the place where the number occurs, and it appears, according to Professor Sayce, that the word אמה is used as a plural : it may, therefore, be found that the measurement recorded in the inscription refers to something else. The words "height of the rock over the head of the excavation," strictly interpreted, would seem to infer that the excavators were aware of the thickness of the rock above them, that is, of the depth of the channel below the surface of the hill. This they could only ascertain either by measurement at the mouths of the channel, or by running contours over the hill,—just as the accompanying section is constructed from the contours—unless they made a shaft to the surface. This is just what they did, for at a distance of 470 feet from the south end a shaft still exists reaching up to the rock surface. It is covered in above with large fallen blocks, but was no doubt once open and served as a well mouth. The rock surface is 14 feet above the floor of the tunnel, the height of which is 3 feet 8 inches at this point. The thickness of rock is, therefore, about 10 feet "above the head of the excavation" at the shaft. This is

the minimum thickness, as is shown by the section, for towards the north the rock surface is 170 feet above the roof of the tunnel. Perhaps in the end the doubtful word may prove to be מאת "an hundred," of which the first and last letters certainly occur, though the א has not been discerned; and the inscription in such a case would refer, in general terms, to the average thickness of the rock above the aqueduct.

Still more interesting is the question whether the length of "a thousand cubits" can have any connection with the measured length of the canal. It is remarkable that 1,700 feet is very close upon 1,000 cubits of 21 inches, and is also very nearly 1,200 cubits of 17 inches, so that the two readings adopted by Professor Sayce and Mr. Shapira respectively might both be supported on the assumption of a different length for the cubit. It would, however, be a very astonishing coincidence if a tunnel so irregularly excavated should in the end have proved to be exactly a thousand cubits long, and it seems far more probable that the writer of the inscription gives an estimated or approximate length, in round numbers, in which case the inscription has no value as fixing the length of the cubit. I have given, in the *Quarterly Statement* of 1880, a *résumé* of the measurements of the Jerusalem Haram and the Galilean Synagogues, which appear to indicate a length of about 16 inches as that of the Jewish cubit, which was not of necessity the same as the Egyptian cubit.

The average measurement of the human hand, as compared with the length of the Zereth or breadth of four fingers, and of the *sit* or span; and the digit of Maimonides as compared with the contents of an average egg, all agree with this shorter measurement. The "cubit" (or fore-arm) "of a man" cannot be measured so as to give 21 inches, nor could 48 barleycorns be made to measure more than about 16 inches (cf. "Handbook to Bible," pp. 57, 79).

Unfortunately, Mr. Beswick's calculations, which reduces the length of the tunnel to 1,478 feet, is founded on a misconception (*Quarterly Statement*, 1881, p. 295), as the length of the branch from the Virgin's Fountain is not included in the total of 1,708 feet.

We have, however, paid special attention to the question whether any marks of measurement could be found on the walls or roof of the channel, and we obtained measurements of certain distances between marks on the wall, of which a digest is given below. The marks in question are evidently artificial, being square or triangular notches measuring about 1½ inches wide. In one place two of them occur 8 inches apart (half a cubit of 16 inches), which, if it had any weight, would seem to indicate that the measurements were not very carefully taken. It seems impossible, however, to deduce any result of value from the measurements tabulated.

There are marks in other places where iron cramps seem to have been driven some 3 inches into the rock, but these also have no regular interval of occurrence, and a very careful examination of both walls, four times repeated, has failed to show us any other marks or signs than those above-mentioned.

The general impression resulting from an examination of the conduit is that it was the work of a people whose knowledge of engineering was rudimentary. It is well known that in mining it is very difficult to induce the excavator to keep in a truly straight line, the tendency being to diverge very rapidly to one side. It is possible that this is the real reason of the crooked run of the canal; but another reason may have been the comparative hardness of the strata met in mining at an uniform level through a hill, with beds having a considerable dip. It will, however, be observed that, after passing the shaft, the direction of the tunnel changes to a line more truly directed on the Virgin's Fountain. The excavators from the Siloam end became aware, probably, by the impossibility of seeing a light at the head of the mine, when standing at the mouth of the channel, that they were not going straight, and the only means they had of correcting the error, consisted in making a shaft up to the surface to see where they had got to. After ascertaining this, they went straight for about 140 feet, and then diverged gradually to the left; but their general direction, nevertheless, agrees roughly with that of the rock contour, which may be due to following a particular seam of rock.

The northern party were yet more hopelessly in the dark, and the great divergence to the west can only be explained by supposing that they did not know where they were going. They seem to have been guided, at length, by the sound of the picks in the other tunnel, which would be heard at a considerable distance through the soft rock, but even then their course indicates great uncertainty.

It is also apparent that a rivalry must have existed between the two parties, working as the inscription tells us "eagerly;" for the two narrowest parts of the tunnel occur, one on either side of the point of junction. In fact, the excavators must be accused of scamping their work, with the object of showing a greater total length than their rivals, and for this purpose they reduced the size of the excavation to a minimum in which it seems almost impossible that a man could have worked. It is clear, anyhow, that the excavators were not giants, and probable that they were under the average size of the modern peasantry in Palestine.

Another interesting question is the increase of height in the tunnel near the point of junction. This may have been due to the intention of concealing their previous proceedings, but it seems more probable that the reason is to be found in the difference of level between the two channels where they meet. The height of the channel does not appear—according to the section—to bear any relation to the thickness of the rock above, but there must evidently have been some cause for the difference of height in various parts of the aqueduct. There is a fall of a foot in the whole length of the tunnel, but the bottom is coated with very hard mud, so that it is quite impossible to ascertain whether the floor is properly levelled or no. At one point (*h* on enlarged plan) a sudden fall of 4 inches appears to occur in the floor level, and the water becomes deeper within a few steps. From this point, also, the roof begins to rise, and gets gradually higher. In 49 feet from *h* to the point of junction *e*, the tunnel increases from

2 feet 6 inches to 4 feet 8 inches in height. It seems probable, therefore, that the southern, or up-stream tunnel, struck higher by about 2 feet than the floor of the down stream shaft, and that the floor was subsequently lowered as far as *h*, when it was found that the water would flow for the rest of the way to the pool without further alteration. This inference could only be drawn from the fact of the *southern* channel being the highest—which is the case. If the northern channel had been the highest we should probably have found a kind of shoot, instead of a gradual levelling off of the floor. The observation serves, however, to give an independent confirmation of the determination of the point of junction before indicated from consideration of the plan alone.

With all allowances, it is nevertheless remarkable that there should have been so little difference of level between the two tunnels. It would have been easy from the flow of the torrent in the Kedron, to make sure that the Pool of Siloam was lower than the spring; and it would not have been difficult by means of a plummet or of a rude water level of some kind, to preserve the level of the channel floor; but it is extraordinary that the two extreme ends of the channel should differ by only a foot in level, considering that the two ends were started independently.

The two ends of the channel are more lofty than any other part, and near the mouth the tunnel is 12 to 16 feet high. Perhaps this may also be connected with the question of the water level, for the intermittent flow of the Virgin's Pool must have caused considerable difficulties. It is true that at the time of the excavation of the tunnel, the overflow of the spring appears to have been carried off by the "brook that ran through the midst of the land" (2 Chron., xxxii, 4), but some of the water would, nevertheless, run down the channel. If, however, the floor of the tunnel at its upper end had been kept about a foot above the high-water mark until the end of the work, this would have been sufficient to prevent any flow down the tunnel. The height of the aqueduct at the upper end is $2\frac{1}{2}$ feet, and it increases rapidly to 6 feet in 20 feet distance, after which it decreases gradually to about 3 feet. This might be explained by supposing that the tunnel was purposely at first run up-hill for a short distance to prevent the water entering, and was afterwards enlarged by sinking the floor so as to admit the overflow when the natural outflow of the Virgin's Pool down the Kedron valley was stopped.

The enlargement at the southern end may also be due to the sinking of the floor after the junction had been effected. It may have been found that the water stood in the tunnel and could not flow into the pool. The excavators would then cut away the rock floor until the water ran through, and the roof would consequently be higher above the water than near the centre where the water was standing. In this case, it seems to have been merely accidental that the levels of the tunnels near the point of junction were so nearly the same, and the differences of height in various parts are seen to be easily explained, on the theory that the aqueduct required considerable alteration after the junction had been effected, and the water

admitted into the upper part of the channel in order to obtain an outflow at the pool of Siloam.

I have thus enumerated all the points which seem to me of importance, as bearing on the method of construction of the canal, and its relation to the wording of the inscription. The number of small bends and irregularities in the course of the tunnel shows, not less than do the larger irregularities, that it was the work of primitive engineers, unacquainted with any very accurate instruments or methods of measurement. Such rock-cut channels are found in other parts of Palestine (as at 'Askar, near Shechem, Sheet XI; at 'Anîn, Sheet VIII; or at Lejjûn, Sheet VIII), but the Siloam tunnel is the most important work of the kind yet discovered. The sides are covered up to a height of about 3 feet with a thin red cement, very hard, and full of pounded pottery, being exactly similar in constitution to that now used in Palestine for lining cisterns. The cracks in the rock are in many places filled in with similar cement above the 3-feet level. In other places the rock has been cut away so as to form a little drain, by which a small land-spring could be led into the channel.

The lower part of the channel has been widened slightly in the parts where the tunnel is highest, the walls being scooped out some 3 inches on either side to a height of about 2½ feet. There is also a shaft or standing place at 700 feet from the south end. It is 7 feet high from the floor, and the roof is of rock. Possibly it was made by the excavator to rest himself in by standing upright after working for a long time in a recumbent position, for it is near the lowest part of the tunnel. It may also have been constructed for safety when the sudden overflow of the spring filled the tunnel, for his head would be high above the water if he sat or stood under this shaft.

We did not observe any side entrance into the channel at any point, and the walls and roof are of solid rock throughout. The initials J. A. S. H. M., and date 1835, are burnt with the smoke of a candle on the roof of the tunnel at 240 feet from the southern end.

In connection with this tunnel I may add a few words as to the new aqueduct recently discovered by the Fellahin. It was not apparently examined by Dr. Guthe, and only a small part of it is at present visible. The level of the top of the covering stones is about 2,091 feet at the point observed. The stones are 1 foot thick, and the channel beneath is at least 2 feet deep, and probably more, as it is filled up with rubbish. This gives a level 2,088 feet, which is a foot above the level of the bottom of the pool of Siloam, from which this aqueduct appears to have led. The channel is rock-cut, 3½ feet wide, and roofed with slabs of stone. In some of these there are slits about 3 inches wide and 20 inches long, but the object of these openings is not clear, unless they served for air holes to relieve the pressure. The aqueduct appears to follow the contour of the hill, westwards from Siloam, and the Fellahin, who have not discovered the end of it, suggested that it went to the Bîr Eyûb, where it will be remembered Colonel Warren found an unfinished subterranean channel. The difference of level is,

however, too great to allow of the two being probably connected. It would be very interesting to follow up the aqueduct from both ends, especially as it may furnish the real explanation of the expression that Hezekiah "Stopped the watercourse of the upper spring and brought it straight down to the west side of the City of David" (2 Chron. xxxii, 30), thus throwing some light on the vexed question of the position of this part of Jerusalem. It is quite possible that subterranean reservoirs, as yet unknown, may exist in connection with this aqueduct, for the Bîr Eyûb itself was long quite unknown, and was recovered in the middle ages by excavation.

C. R. C.

TABLE OF DISTANCES.

Siloam Tunnel.

The Zero marks the commencement of a series of measurements between two or more notches.

	Feet.	16-inch cubit.	17·72-inch cubit.	18-inch cubit.	21-inch cubit.
Notch A	0	0	0	0	0
,, B	$\frac{8}{12}$	·5	·45	·44	·38
,, C	$57\frac{6}{12}$	43·12	38·43	38·33	32 86
,, D	0	0	0	0	0
,, E	$41\frac{10}{12}$	31·37	28·33	27·87	23·90
,, F	0	0	0	0	0
,, G	$12\frac{8}{12}$	9·5	8·57	8·44	7·24
,, H	0	0	0	0	0
,, I	$15\frac{9}{12}$	11·37	10·27	10·11	8·69
,, J	0	0	0	0	0
,, K	$25\frac{6}{12}$	19·12	17·27	17·	14·57
,, L	$24\frac{6}{12}$	18·37	16·59	15·93	13·52
,, M	$9\frac{6}{12}$	7·12	6·43	6·33	5·43