roots, one minimal and the other maximal. In such cases the line passes through the 'centre of gravity' of the observed points. This is only true for the solution of (5) if we regard the centre of gravity to be that found after applying a weight $w_{r}$ to each point.
Trumpler and Weaver ${ }^{5}$ ( p .184 ) say that in twoerror solutions the parameter estimates depend upon the 'distribution of', in our notation, the ( $x_{r}, y_{r}$ ) about the diagram. In fact, Seares's solution was via regression lines from which the systematic effects associated with the distribution of the ( $x_{r}, y_{r}$ ) had been removed and this is why the distribution entered into the argument. Here, we proceed directly from a separate consideration of each point and it is only afterwards that, for example in (7), the marginal variances of the $x_{r}$ and $y_{r}$ distributions appear.

Some prior knowledge of the $s_{r}$ and $t_{r}$ is, of course, fundamental to a completely meaningful approach to the problem but useful applications of equations (5) and (6) are likely to occur where a problem can be put into the form of solving for the least-squares linear relation only at the expense of introducing widely varying precision for the different observed values of both quantities.
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* On secondment from the Royal Greenwich Observatory. ${ }^{1}$ Seares, F. H., Astrophys. J., 100, 255 (1944).
${ }^{2}$ Seares, F. H., Astrophys. J., 102, 366 (1945).
${ }^{3}$ Hertasprung, E., Leiden Ann., XIV, Eerste Stuk (1922).
"Jeffreys, H., "Theory of Probability", 164 (Oxford University Press, 1939).
${ }^{5}$ Trumpler, R. J., and Weaver, H. F., "Statistical Astronomy" (Univ. of California, 1953).


## HISTORY OF SCIENCE

## The Value of $\pi$ and the Old Testament

Many recent authors of texts containing an account of the historical development of the numerical value of $\pi$ write under the misapprehension that in the Old Testament its apparent value is 3 . Concerning this value, Prof. E. T. Bell writes": "This approximation to $\pi$ is famous for its occurrence in the Old Testament". Quoting 2 Chron. 4, 2, Prof. L. Hogben deduces " "The ancient Hebrews were content with taking $\pi$ as 3 ". The late Prof. G. H. Hardy could scarcely have examined his two quotations, otherwise he would not have made the blunt observation ${ }^{3}$ : "It is stated in the Bible that $\pi=3$ ". P. Dubreil quotes ${ }^{4} 1$ Kings 7, 23, and contrasts the approximation with Shanks's value of $\pi$ to 707 decimal places. Quoting 2 Chron. 4, 2, Prof. T. Dantzig comments ${ }^{5}$ that this description indicates that the Jews held that $\pi$ is equal to three. Very recently, Archbold quotes ${ }^{6}$ Dubreil that the Bible gives the value of $\pi$ as 3, thereby perpetuating the error in the minds of the next generation of students who read his text. These writers therefore fall into two classes, the first regarding $\pi$ as actually given by 3 , and the second regarding the measurements given as only approximate. Even some Biblical commentators have fallen into similar error; for example, Curtis and Madsen in their commentary ${ }^{7}$ on 2 Chron. 4, 2 suggest that the numbers are only approximations.

A careful reading of the verses following 1 Kings 7, 23 is sufficient to dispose of this approximation, quite
apart from consulting the works of those who have sought to restore the "molten sea" from the Biblical dimensions. For it transpires that the circumference of 30 cubits and the diameter of 10 cubits do not refer to the same circle, so it is impossible to conclude that $\pi$ was taken as 3 , either mistakenly or approximately.

The diameter of the "molten sea" at its extreme top from brim to brim was 10 cubits. But in 1 Kings 7, 24, we must interpret "under the brim of it round about there were knops compassing it". The word 'under' may imply that the external surface of the brim need not have been vertical ; the cylindrical sides of the "sea" were inclined outwards in order to form the brim, yielding a smaller circle around which the knops (gourds or wild cucumbers) were cast under the slightly larger circle formed by the brim. This is confirmed by verse 26 , where we read that "the brim was wrought like the brim of a cup, with flowers of lilies", for Sir W. Smith's dictionary ${ }^{8}$ interprets this as meaning that the brim was curved outwards like a lily or lotus flower, giving at the same time the literal translation of the Hebrew text: "its lip was like work such as a cup's lip, a lily flower'". The " 30 cubits compassing the sea round about" (verse 23) refers then to the general circumference of the "sea" below the brim and not to the special circumference around the brim. Thus the circumference of the brim must have been $10 \pi$ cubits, and the diameter of the cylindrical wall of the "sea" below the brim must have been $30 / \pi=9.55$ cubits; these irrational measurements are omitted from the text.
Even the commentators have often missed this point. Montgomery and Gehman ${ }^{9}$ state that the dimensions are only round figures, thereby failing to see that there is nothing in the text ( 1 Kings 7, 23-26) that suggests that the figures 10 and 30 refer to the same circle, although their literal translation, "a lily-shaped brim", implies circles of varying diameters.
These observations may be verified by noting that Sir W. Smith's dictionary ${ }^{8}$ gives a general sketch of the "sea" according to the restoration by Keil ; a distinct outwardly curving brim exists, with the rows of knops underneath it. A larger encyclopædia ${ }^{10}$ gives a detailed etching of the restoration according to Calmet, together with a complete axial crosssection of the "sea"; this too shows the characteristic brim, with the rows of knops below it around a circle of smaller diameter than that of the brim.

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West Ham College of Technology, London, E. 15. April 7.
${ }^{1}$ Bell, E. T. "The Development of Mathematics", 40 (McGraw-Hill, New York, 1945).
${ }^{2}$ Hogben, L., "Mathematics for the Million", 251 (Allen and Unwin, London, 1940).
${ }^{3}$ Hardy, G. H., "A Course of Pure Mathematics", 70 (Cambridge, 1952).
"Dubreil, P., "Les Grands Courants de la Pensée Mathématique" edit. by le Lionnais, F., 99 (Cahiers du Sud, 1948).
${ }^{5}$ Dantzig, T., "Number, the Language of Science", 113 (Allen and Unwin, L'ondon, 1947).
"Archbold, J. W., "Algebra", 5 (Pitman, London, 1958).
${ }^{7}$ Curtis, E. L., and Madsen, A. A., "The International Critical Commentary ; The Books of Chronieles", 331 (Clark, Edinburgh 1910).
s Smith, W., "A Dictionary of the Bible", 3, 1172 (Murray, London, 1893).
${ }^{9}$ Montgomery, J. A., and Gehman, H. S., "The International C'ritical Commentary; The Books of Kings', 173 (Clark, Edinburgh, 1951).
${ }^{10}$ Singer, I., "The Jewish Encyclopedia", 3. 357 (Funk and Wagnalls, New York, 1925).

