MEDIEVAL CHURCH SUNDIALS.

An Historical Sketch reproduced from "Scratch-dials and Medieval Church Sundials."

By T. W. Cole.

The sundial shown as Fig. 1 is perhaps the most interesting in this country, certainly it is the most significant. This dial forms part of the decorative design on the seventh- or eighth-century cross in the churchyard at Bewcastle, Cumberland, and was carved by some Saxon or foreign mason under the direction of the early monk-missionaries who at that time were drawing extensively on the art treasures of the East and possibly introducing into this country refugee-craftsmen who were immigrating into Europe to escape from the Mohammedan invasion under which Syria and Egypt were then suffering. The richly sculptured ornamentation on this cross has affinity with Syrian and Alexandrian art and resemblance has been traced so far as part of the design is concerned to certain fifth century reliefs preserved in the museum at Cairo. The sundial itself looks like a design from the East as it would tell the time with considerable accuracy in mid-Egypt, in fact an Egyptian sundial with similar hour-divisions, dating from about the 13th century B.C. is still in existence.

The incorporation of a sundial in the ornamentation on this cross was primarily religious, in fact it is a specialised way of carrying out the general purpose of the cross itself, namely that of furnishing a perpetual reminder of our Lord's sacrifice. The sundial, formed by radiating lines dividing a semi-circle into twelve equal parts (each representing one hour of the sun's travel from sunrise to sunset) seems mapped out so as to be commemorative of the first Good Friday by crossing the lines of the hours identified in the Gospels with the death and passion of our Lord (third, sixth and ninth). It is thus correlative with the sequence of personal daily devotions (terse, sext and none) observed by Christians from very early times, especially by those in the monastic orders.

Saxon Dials and Scratch Dials.

This imported type of dial (of which Bewcastle is the earliest at present known) seems to have furnished succeeding generations of Saxon masons with a kind of model for cutting dials for the south walls of churches. A similar dial cut probably a couple of centuries or so later, with Eastern fret decoration and with crosses on the third, sixth and ninth hour-lines, can be seen over the porch at Bishopstone church, Sussex. Other Saxon dials, with or without ornamentation and varying in the number of hour-lines but still with the characteristic crossing of some of them, can be seen at Warnford and Corhampton (Hants), Daglingworth (Glos.), Lullington (Somerset), Kirkdale (Yorks) and elsewhere. But with the passage of the centuries, despite the

(*From a cast in the Science Museum, South Kensington.*)

FIG. 1.
Dial is weather-worn by over a thousand years exposure. The vertical indentation on right-hand side is merely a mutilation.

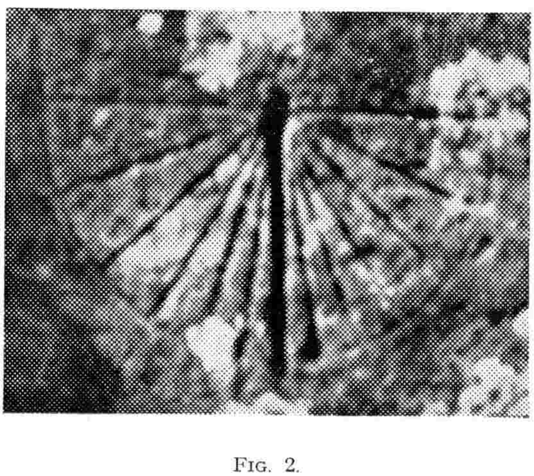


FIG. 2.

fact that knowledge and skill were generally on the increase all round, these accurately-cut dials degenerated into the rudely scratched, amateurish efforts, consisting merely of a few lines radiating from a common centre that can still be seen on the south walls of more than 1,300 of our ancient parish churches,* and which discarding any pretence at uniform time-keeping contented themselves with recording at best a merely proportional division of the day. These haphazard time-devices satisfied Medieval England from apparently the Norman days till towards the end of the fourteenth century.

The explanation of this degeneracy of an accurately designed dial (of the Bewcastle type) into a wholly unsystematic "scratch dial" was presumably due to the fact that although the former type of dial told the time with reasonable accuracy in the place of its origin, Egypt, or without much error in Palestine under the system in vogue it became practically useless as a time-device when transported as far north as England. (The exact performance of such a dial in different countries and the increasing inaccuracy as it travels northwards say, from Egypt, can be easily seen by the geometrical methods of examination outlined in subsequent pages).

MEDIEVAL TIME SYSTEM.

The time-system associated with these dials and which remained in vogue in England until the introduction of clocks in the second half of the fourteenth century (though mainly as a dim religiously-coloured background since there was no time-device in general usage to bring such system into effective use) was the same as obtained in Palestine in the days of our Lord. This time-system we can easily reconstruct owing to the precision with which the New Testament writers record the time of day at which events took place. We know that there were twelve hours in the day (John xi, 9) and that the hours were numbered from sunrise to sunset, one to twelve (Matt. xx, 1 to 12). Mention is made of the third and sixth hours (Matt. xx, 3 and 5), the seventh (John iv, 52), the ninth (Matt. xx, 5), the tenth (John i, 39), the eleventh (Matt. xx, 6), and the twelfth (John xi, 9). Also the "hour" as a unit of time was generally understood, as we see by the mention of the duration of an hour (Luke xxii, 59), two hours (Acts xix, 34), of three hours (Acts v, 7), and of half-an-hour (Rev. viii, 1). The only time-device with which all and sundry, especially in rural districts, could have been thus familiar seems to be the sundial, and we may reasonably assume that the kind used would be the Egyptian type of which Bewcastle is a copy. (The geometrical methods given later will show the limits of accuracy with which this kind of dial would tell the time in Palestine).

The inability of the English medieval mind to devise a workable sundial is shown, not only by its tolerating for so many centuries the wholly insufficient scratch-dial, but also by the fact that even when

*For list of churches, under counties, see author's "Origin and Use of Church Scratch-Dials," 4d.

clocks came in and so provided a standard of time-keeping, there was still the same failure to produce a true sundial. Experiments were certainly made and these unsuccessful attempts (fourteenth and early fifteenth centuries) can still be seen on church walls, some easily recognisable by the hour-lines being numbered, usually in Roman figures, from 6 a.m. to 6 p.m. in the new clock notation. But the clue still evaded the dial-maker and throughout these numerous trials he failed to notice that the shadow of the pointer-tip fell on the same straight line at the same hour every day throughout the year. Consequently the construction of a true sundial was deferred until about the fifteenth century when the increasing mathematical and astronomical knowledge enabled a true sundial to be made from first principles.

Behaviour of Vertical Dials with Straight Pointer.

The geometrical construction on the page opposite, which can be drawn with a fourpenny transparent (semi-circular) protractor, shows the time at which the shadow from the straight pointer of a vertical (south-facing) dial will fall on any of the lines cut on such dial.

The lower dial in the diagram is the dial under examination. The upper dial is numbered clockwise (being half-face of a twenty-four-hour clock) so that the respective times can be read off. The lower dial (reversed) has been turned upside down so as to bring it into working relation with the timing dial. Only half of each is shown, the other half is merely a replica.

The example taken for examination is a dial of the Bewcastle type where the lines are spaced at regular intervals of 15 degrees. Place—England (52 degrees latitude) in May.

To read the time of any shadow on the lower dial, trace the line upwards to where it crosses the upper half-circle and note the hour as numbered.

Construction :

Draw half of a 24-hour clock face.

Pick out time of sunrise (4 o'clock) and draw line therefrom to A (at right angles to mid-day line).

At B draw BC at 52 degrees to AB, and draw BE at right angles to AB.

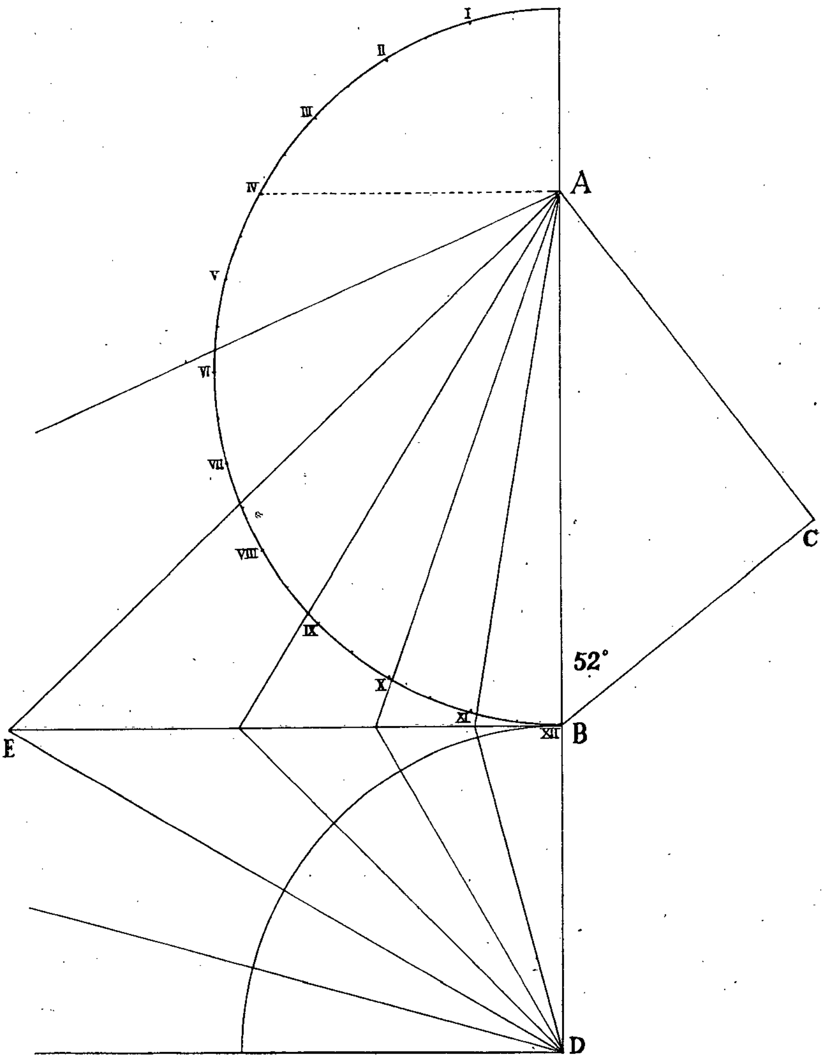
Draw AC at right angles to BC.

Produce AB to D, making BD equal to BC.

Set out from D (the position of straight pointer on this dial) the lines on the dial under examination, and produce to line BE.

Where these lines intersect the horizontal line BE draw lines to A, the time required being given where such lines cross the numbered circle of the clock-face.

For the reverse operation, namely, where it is required to know in what position a shadow will fall on the vertical dial at any given time, begin with same construction but with no radiating lines (so that both dials are blank). Draw A at sunrise as before. Draw lines from A to EB passing through the hour required and continue same from intersection to D. The line to D will give the angle of shadow required.



To use the construction to show the performance of dials under the medieval time-system, the upper dial in the diagram should be renumbered as follows. The period of time from sunrise to mid-day should be divided by six and divisions be marked along the rim of the dial accordingly. For example, with sunrise at 4 a.m. the minutes to midday would be 480, which divided by 6 gives 80 minutes to the medieval hour for that day. As one degree equals 4 minutes, each hour-division on the dial would be 20 degrees.

Various considerations arise from this construction, for example, the lines on the upper dial are those of a modern vertical scientific dial, and the angle BAC gives the position of gnomon for the latitude taken, while the lower dial, in the position BC and equipped with a pointer AC at right angles is an equatorial dial recording one hour for every 15 degrees of the dial.

Relation of Scratch-Dials to Scientific Sundials.

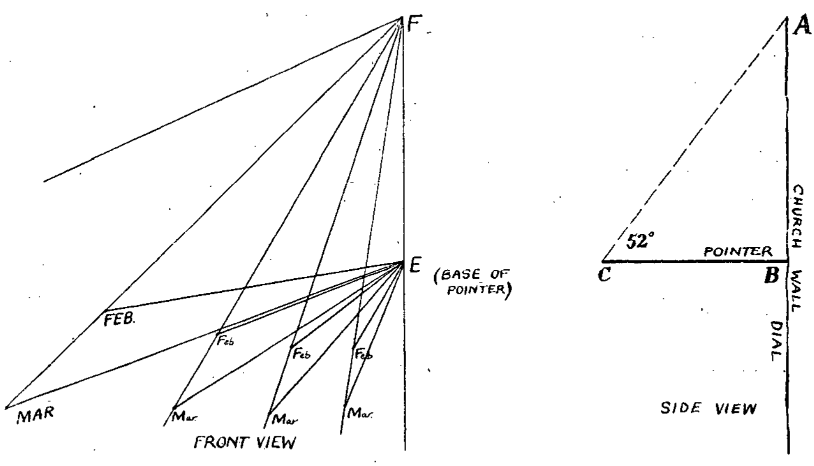
It was remarked on a previous page that medieval dial-makers missed the clue by which a true sundial might be made empirically. The following diagram shows how a scientific sundial might be made from observation and without recourse either to mathematical or to astronomical knowledge.

The " side-view " diagram shows a south-facing dial with BC as its pointer. Assume that E is the position of the pointer when the dial is viewed face-on. The pointer would throw shadows in February at 8, 9, 10 and 11 o'clock as shown. In March shadows at the same hours would differ in length and direction as drawn on diagram. Applying the clue referred to, namely that the shadow of the tip of the pointer falls on the same straight line at the same hour every day alike, we can construct a scientific sundial by drawing a line connecting the shadow tips of each pair of hours respectively. It will be seen in the diagram that the lines for 8, 9, 10 and 11 meet at a point F vertically above E. (The same would follow upon the remaining hours being similarly dealt with).

The hour lines thus obtained correspond exactly with those set out in the upper dial of diagram on page 5 (where they are drawn from astronomical principles).

The required gnomon is obtainable as follows. Fix point A (in the " side-view " diagram) so as to correspond with the point F. Join AC. The shadow of AC will lie lengthwise on the respective hour-lines. The angle BCA gives the latitude of place in which operations were taken.

It will be noted from inspection of the diagram below that the pointer CB whose shadow the medieval dial-makers followed, is really



the horizontal member of a scientific gnomon. But both the gnomon and the pointer have one point in common, namely, the tip C. It is through this point in common (the hasdow of the " tip ") that relationship can be established between scratch-dials and scientific dials, as indicated in the present diagram. The diagram also indicates how, if the angle of the shadow cast by a straight pointer is known, the length of such shadow can be determined.

GENERAL NOTES.

In the geometrical construction on page 152 the time of sunrise is a factor. The following corresponding times of sunrise are given as being usable for purpose of comparison :—

	Jan.	Feb.	Mar.	Apr.	May	June
	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.
Mid-Egypt	6.36	6.16	5.55	5.33	5.16	5.08
Palestine	6.50	6.23	5.55	5.24	5.01	4.50
England	7.45	6.50	5.52	4.50	4.00	3.38

It should be noted that the geometrical constructions outlined are correct relative only to sun-time and for the purpose in hand, namely to ascertain within reasonable limits how medieval sundials behave as compared with a true sundial and the effect of transferring a sundial from country to country. In this connection I must express my great indebtedness to Mr. D. H. Sadler, M.A., F.R.A.S., for his generous assistance. (But it would ill-requite his kindness if such thanks were in any way interpreted as suggesting any responsibility for the general notes or the historical sequence suggested.)

The kindness of the Rector of Bewcastle (Rev. N. C. Murray) should also be acknowledged. The Rector considers that the cross is standing in its original position, with the dial facing south (the position for use).

The processes determining the behaviour of dials can be abbreviated or assisted by the use of tables such as given in the " Nautical Almanac " (Stationery Office, 6s.) with its authoritative chapters on the calendar and time. An abridged edition (without the latter) is published at 2s. 6d. and the tables of sunrise and sunset only at 1s. 6d.

As a general introduction to time and the principles of measurement and early devices for so doing, the prefatory notes written by Dr. F. A. B. Ward to his handbook (Part I) to the collection of time-measuring instruments in the Science Museum, South Kensington, is admirable for its succinct summarising of up-to-date knowledge and opinion on the matters involved (Stationery Office 1s. 6d.).

The historical references to the sculpture on the Bewcastle cross are taken from the " Handbook of English Medieval Sculpture," by Mr. Arthur Gardner, who, as to Anglian sculpture generally refers to Baldwin Brown's " Arts in Early England." (For the association of the dial with the surrounding ornamentation and the resulting implications the present writer is alone responsible).

General Use of Geometrical Constructions.

The geometrical constructions given in this booklet in connection with medieval dials are also applicable with appropriate modification, to any types of sundial.

Ancient sunclocks, say of Egypt, can be examined as to performance, by application of these constructions, since there can be derived from them the behaviour of a shadow at any hour of the day on any day of the year, in any country, the only data required being the latitude of the place and the time of sunrise on the day taken.

Instead of a geometrical construction the following trigonometrical formula will give the angle from noon line of shadow cast by a straight pointer on a vertical south-facing dial at a given hour.

$$\cot D = \frac{\cos A \pm \sin B}{\sin A} \cos C$$

where D is angle required, A is hour-angle on equinoctial dial (or 24-hour clock face), B is hour-angle between sunrise and 6 o'clock line, and C degree of latitude (+ if sunrise before 6 a.m., — if sunrise after 6 a.m.).

The corresponding formula for shadow cast by a straight pointer on a horizontal dial is :—

$$\cot D = \frac{\sin A \mp \sin B \, (\cot C)^2}{\cos A} \sin C$$

(— if sunrise before 6 a.m., + if sunrise after 6 a.m.).

The type shown in Fig. 2 (Litlington, Sussex) marks the end of the quasi-religious scratch-dials of the previous centuries, and typifies the emergence of the secular sundial. It will be seen that the angles of the hour-lines correspond with those on the scientific sundial (upper part of first diagram) and the dial would have been cut in or after the fifteenth century. Its unique character lies in the fact that it is a scientific sundial disguised as it were, as an early scratch-dial.

(Sketches and geometrical diagrams by W. Oliver.)