*ΟI* from *O* on *AR,* and first suppose the joint *A* to be clamped. Then, if *I* is in *AR* produced, a rotation of the instrument about *O* with angular velocity ω will give to *R* the component velocities *OI.ω* in the direction *IR* and *IR.* ω in the direction perpendicular to *IR,* and will therefore compel the roller to turn with the angular velocity *RI/r*ω ; but, if *I* is on the other side of *R,* the angular velocity of the roller will be -*RI/r*ω. Therefore, keeping *A* clamped, the roller will turn through an angle *RI/rθ* or -*RI/rθ,* according as *I* is or is not on the same side of *R* as *A,* when the instrument is rotated through an angle *θ* about *O* ; but, when *I* coincides with *R,* the roller will not turn, and then *P* describes a circle, called the “zero circle,” represented by the middle dotted circular line, of radius

√(*OR2 + RP2)* = √{*a*2 - *c*2 + (*b* + *c)2*} = √(*a*2 + *b2* + 2*bc*).

Next unclamp the joint *A* and clamp the arm *OA* ; then the roller will turn through an angle -*c*/*rφ,* while *AP* turns through an angle *φ.*

Now suppose *P* to travel round the finite circuit *PP1P2P3* by a combination of the preceding motions in the following order. (1) Clamp the joint, and move *P* to *P1* and *A* to *A1* on arcs of circles of centre *O* ; then the roller will turn through an angle *RI/rθ,*

*θ* being*=AOA1=POP1.* (2) Unclamp the joint and clamp the arm, and move the pointer from *P1* to *P2* on the arc of a circle of centre *A1* ; then the roller will turn through an angle = -c/r *φ,φ*

being *= P1A1P2,* (3) Unclamp the arm and clamp the joint, and

move the pointer from *P2* backwards to *P3* and *A1* to *A,* on arcs of circles of centre *0,* through an angle *0* ; then the roller will turn through an angle *RI/rθ,* if *OI1* is the perpendicular from *O* on *P3A.*

(4) Unclamp the joint and clamp the arm, and move the pointer from *P3* to *P* on the arc of a circle of centre *A,* and consequently through an angle *φ ;* the roller will turn through an angle *φ,*

which cancels the angle due to motion (2). Thus in completing the finite circuit *PP1P3P3* the roller will have turned through an angle *(RI-RI*1) θ/r *=(AI- AH)* θ/r*.*

But the area PP1P2P3 = area *PP1Q1Q,*

= sector *OPP1*- sector *OQQ1=1/2 (OP2 - ΟP32)θ, =1/2{OA2 + AP2 + 2AI.AP-(OA2 + AP2*

*+2AI1.AP)} θ,*

*= (AI-AI1) bθ,*

*= br* times the angle turned through by the roller.

The area *PP1P2P3* is therefore *b* times the travel of the circum­ference of the roller.

Any irregular area, supposed to be built up of infinitesimal ele­ments found in the same manner as *PP1P2P3,* will be accurately measured by the roller when the point *P* completes a circuit of the perimeter, the arm *AP* being free to turn on the joint at *A* and the arm *OA* on a fixed point *O.* If, however, *O* is inside the area, the area of the zero circle must be added to the area deduced from the readings of the roller. When the roller is fixed permanently, this area is constant, and is usually engraved on the arm in units of the adopted length *b* ; when the roller is held on a slider which also carries the pinion of the arm *OA,* the length *b* may be so adjusted that the areas described will be expressed in any desired unit of measure.

*Literature* *and* *Authorities consulted.—Accounts of the operations of the Great Trigonometrical Survey of India ; Manual of Survey for India ;* Col. A. R. Clarke, *Geodesy ; Methods and Processes of the ordnance Survey ;* Col. Water- house, *on the Application of Photography to Maps and Plans* ; and *Professional Papers of the Royal Engineers.* (J. T. W.)

SUSA, the Biblical Shushan, capital of Susiana or Elam and from the time of Darius I. the chief residence of the Achæmenian kings, was a very ancient city, which had been the centre of the old monarchy of Elam and undergone many vicissitudes before it fell into the hands of the Persians (see Elam). The site of the town, which has been fixed by the explorations of Loftus and Church­ill, lies in the plain, but within sight of the mountains, between the courses of the Kerkha (Choaspes) and the Dizful, one of the affluents of the Pasitigris. The Shápúr, a small tributary of the Dizful, washes the eastern base of the ruin-mounds of Sús or Shúsh. Thus the whole district was fruitful and well watered, fit to support a great city ; the surrounding rivers with their canals gave protection and a waterway to the Persian Gulf ; while the position of the town between the Semitic and Iranian lands of the empire was convenient for administrative purposes. It is not therefore surprising that Susa became a vast and populous capital ; Greek writers assign to it a circuit of 15 or 20 miles,—a statement which is fairly well borne out by the remains. These include three main mounds, of which one is identified with the strong citadel@@1 and a second shows the relics of the great palace built by Darius I. and completed by Artaxerxes Mnemon. Susa was still a place of importance under the Sasanians, and after having been razed to the ground in consequence of a revolt seems to have been rebuilt by Shápúr II. under the name of Éránshahr-Shápúr (Nöldeke, *Gesch, d. Perser aus Tabari,* p. 58). The fortifications were destroyed at the time of the Moslem conquest (Mokaddasi, p. 307) ; but the site, which is now deserted, was inhabited in the Middle Ages, and a seat of sugar-manufacture.

In Daniel viii. 2 the river of Shushan is called Ulai, a name which is identical with Avrai of the Bundehesh and Eulæus of classical writers. What is told of the Eulæus makes it impossible to identify it with the inconsiderable Shápúr ; but authorities differ as to whether it is another name for the Choaspes or rather denotes

the Dizful or the Pasitigris. Susa in the days of its greatness must have stretched nearly from river to river. There is a sanc­tuary of the tomb of Daniel on the banks of the Shápúr, and Arabic geographers relate that this tomb was a frequented shrine before the Moslem conquest and that the Arabs turned the stream over the grave.

SUSA, a city of Italy, in the province of Turin, 331/2 miles west of Turin by the railway which passes by the Mont Cenis tunnel into France, is situated on the Dora Riparia (tributary of the Po) at 1625 feet above the sea, and is so protected from the northern winds by the Rocciamelone that it enjoys a milder winter climate than Turin itself. The city walls, 20 to 30 feet broad at the base, were about 50 feet in height, but in 1789 their ruinous condition caused them to be reduced by about half their elevation. Numerous remains of Roman buildings and works of art still show the importance of the ancient town ; and the triumphal arch erected by Cottius in honour of Augustus still stands on the old Roman road between Italy and Gaul,—a noble structure, 45 feet high, 39 broad, and 23 deep. The inscription, now illegible, mentioned fourteen “ civitates ” subject to Cottius. Among the modern buildings of Susa the first place belongs to the church of San Giusto, founded in 1029 by Olderico Manfredi II. and the countess Berta, and in 1772 raised to be the cathedral. The population of the city was 3254 in 1871 and 3305 in 1881 (commune, 4418).

Segusio (also Secusio, Siosium, Seutium, Seucia, &c.) was at a very early period the chief town of this Alpine region, and the Cottian Alps themselves preserve the name of the Segusian chief Cottius, who with the title of præfectus became a tributary and ally of Rome in the reign of Augustus, and left his state strong enough to maintain its independence till the reign of Nero. As a Roman municipium and military post Segusio continued to flourish. After the time of Charlemagne a marquisate of Susa was established ; and the town became in the 11th century the capital of the famous countess Adelaide, who was mistress of the whole of Piedmont. On his retreat from Legnano, Barbarossa set fire to Susa ; but the town became more than ever important when Emanuel Philibert fortified it at great expense in the 16th century.

SUSA *(Susa),* a city of Tunis, on the coast of the gulf of Hamáma, 33 miles south of Hamáma. It occupies the side of a hill sloping seawards,· and is still, as far as the town proper is concerned, surrounded with heavy white-

@@@1 The Greeks called the citadel the Mε*μvόvιov* (Strabo, xv. 3, 2), and supposed it to have been founded by the Ethiopian Memnon. It was strong enough to withstand Molon in his war with Antiochus the Great (Polyb., v. 48).