"*On an uniform System of Screw Threads.*" By Joseph Whitworth, Assoc. Inst. C. E.

The subject considered in this paper, is the importance of having a constant thread for a given diameter in all screws used in fitting up steam engines and other machinery. It is argued, that uniformity of thread would be productive of economy, both in the use of screwing apparatus, and in the consumption of bolts and nuts. The refitting shop of a railway or steam packet company affords a striking instance of the advantage to be derived from the application of this principle. If the same system of screw threads were common to the different engines, a single set of screwing tackle would suffice for any repairs. No attempt appears to have been hitherto made to attain this important object. Engineers have adopted their threads without reference to a common standard. Any such standard must be in a great measure arbitrary, and hence its absence may be accounted for.

The author enters at some length into the consideration of the circumstances affecting the choice of a thread, with a view to show that it cannot be determined by precise rules. The essential characters of the screw thread are—pitch, depth, and form. The required conditions are—power, strength, and durability. But the exact degree or proportion in which these conditions are required, cannot be ascertained, and consequently the characters on which they depend cannot be fixed by calculation. An approximation may be made, but within a certain limit the decision is arbitrary. The mutual dependence of the several conditions, and the relation subsisting between the constituent characters, are noticed as having a tendency to perplex in the choice of a thread. From the vagueness of the principles involved in the subject, a corresponding latitude was naturally to be expected in the practical application of them, and accordingly, instead of that uniformity which is so desirable, there prevails a diversity so great as almost to discourage any hope of its removal. The only mode in which this could be effected, would be by a compromise; all parties consenting to adopt a medium for the sake of common advantage. The average pitch and depth of the various threads used by the leading engineers, would thus become the common standard, which would not only have the advantage of conciliating general concurrence, but would in all probability approach very nearly to the true standard for practical purposes.

The author then proceeds to describe the mode adopted by Messrs. Whitworth and Co., some years since, in selecting their threads upon this principle. An extensive collection was made of screw-bolts from the principal workshops throughout England, and the average thread was carefully observed for different diameters. The ¼ inch, ½ inch, and 1½ inch, were particularly selected, and taken as the fixed points of a scale by which the intermediate sizes were regulated, avoiding small fractional parts in the number of threads to the inch. The scale was afterwards extended to 6 inches. The pitches thus obtained for angular threads were the following:—

Diameter in inches.	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1″	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2″
No. of threads to the inch.	20	18	16	14	12	11	10	9	8	7	7	6	6	5	5	4½	4½
Diameter in inches.	2¼	2½	2¾	3″	3¼	3½	3¾	4″	4¼	4½	4¾	5″	5¼	5½	5¾	6″	
No. of threads to the inch.	4	4	3½	3½	3¼	3¼	3	3	2⅞	2⅞	2¾	2¾	2⅝	5⅝	2½	2½	

Above the diameter of 1 inch the same pitch is used for two sizes, to avoid small fractional parts. The proportion between the pitch and the diameter varies throughout the entire scale. Thus the pitch of the ¼ inch screw is 1/5 of the diameter; that of the ½ inch 1/6, of the 1 inch ⅛, of the 4 inches 1/12, and of the 6 inches 1/15. The depth of the thread in the various specimens is then alluded to. In this respect the variation was greater than in the pitch. The angle made by the sides of the thread being taken as an expression for the depth, the mean of the angle in 1 inch screws was found to be about 55°, which was also nearly the mean in screws of different diameter. Hence it was adopted throughout the scale, and a constant proportion was thus established between the depth and the pitch of the thread. In calculating the former a deduction must be made for the quantity rounded off, amounting to ⅓ of the whole depth, *i. e.* 1/6 from the top, and 1/6 from the bottom of the thread. Making this deduction, the angle of 55° gives for the actual depth rather more than ⅗, and less than ⅔ of the pitch.

It is observed that the system of threads thus selected has already been widely extended, demonstrating the practicability and advantage of the proposed plan. The author then notices the obstacles to general uniformity arising from the inconvenience which any change would occasion, in existing establishments, and also from the imperfect screwing tackle in general use. He anticipates as an important result of a combined effort to introduce uniformity, that screwing tackle generally would be much improved, and the efficiency and economy of bolts and nuts be thereby increased.

He recommends also standard gauges of the diameters and threads, as they would form a convenient adjunct to the screwing apparatus, and would be applicable to other useful purposes.

Mr. Field claimed for the late Mr. Maudslay the credit of the first attempt to introduce uniformity of thread—it was well known how incessantly his attention and skill had been devoted to this object, and with what success his efforts had been attended. He would at the same time accord great merit to Mr. Whitworth, not only for his present effort to introduce a very desirable measure, but also for the general excellency of the screwing tackle made under his directions.

Mr. Seaward corroborated all that Mr. Field had advanced; he had always considered that to Mr. Maudslay the mechanical world was indebted for the accuracy with which screws were now made. He considered the plan proposed by Mr. Whitworth to be good, but difficult of attainment in old-established manufactories, where very extensive assortments of screwing tackle already existed.

The President concurred in the opinion, that it was to Mr. Maudslay's well-known talent and skill that the mechanical world was indebted for the great improvements in the form of the screw, and the mode of its manufacture; but it was to Mr. Whitworth that the Institution was indebted for having brought the subject before the meeting; he trusted that this example would not be lost upon the numerous members, who could contribute so largely to the interests of the meetings, by recording the facts which came under their notice in the course of their diurnal employments.

"*Account of the original construction and present state of the Plymouth Breakwater.*" By William Stuart, M. Inst. C. E.

In the year 1806, the Lords Commissioners of the Admiralty instructed the late Mr. John Rennie, C. E., and Mr. Whidby, then Master-Attendant at Woolwich Dock, to make a survey of Plymouth Sound, with a view to the construction of a breakwater for sheltering vessels.

Their report was favourably received, but it was not until 1812 that the works were commenced.

Their plan consisted of a pier or breakwater 1700 yards in length, the centre part of which, 1000 yards long, was straight, with an extension at each end 250 yards in length, placed at an angle of 20° with the main body. The top to be 30 feet wide at the level of 10 feet above the low water of an ordinary spring tide:—the slope towards the sea to be 3 feet horizontal to 1 foot perpendicular, and on the land side 1 foot 6 inches horizontal to 1 foot perpendicular.

By the middle of March, 1813, the work had been brought up in parts to within 5 feet of low-water mark of spring tides—at this period 43,789 tons of stone had been deposited—and in the month of March of the following year sufficient shelter was afforded for ships of war to anchor in the Sound instead of in Cawsand Bay.

It was then determined to raise the whole structure to the height of 20 feet above low-water spring tides; great exertions were made to complete it rapidly, and during the week ending on the 24th of May, 1816, the quantity of stone deposited amounted to 15,329 tons, which was the largest quantity ever conveyed within the same space of time.

Slight injury had frequently been received by the works whilst in progress, but the storm of the night of the 19th of January, 1817, was the first which materially affected them. The most destructive effects were, however, produced by the storm of the 22nd and 23rd of November, 1824. On that occasion the spring-tide rose 7 feet higher than usual; and so great was its power, that a length of 796 yards of finished work was completely overturned, and the remaining parts slightly injured.

It was observed, that the effects of this storm left the slope from low-water mark upward at about 5 feet horizontal to 1 foot vertical. It was therefore determined to adopt that angle of inclination for the exterior or sea side, and a slope of 2 to 1 for the inside. The centre line of the breakwater was also removed 39 feet 6 inches towards the north, and the top width was increased to 45 feet.

The works continued upon this scale until 1830, when a fore-shore was added of a width of 50 feet at the toe of the south slope at the west end, and of 30 feet at the east end of the main arm: for this purpose 600,000 tons of stone were deposited.

The extreme western end of the breakwater was then, after more alterations and extensions, terminated by a circular head, with an inverted arch as a foundation for a light-house, now constructing under the direction of Messrs. Walker and Burges.

In consequence of further injuries from storms in 1838, when large quantities of stones of 16 or 20 tons' weight each were torn from below low water, and carried completely over the top of the Breakwater, a further extension of the fore-shore was made, and a projecting buttress built to secure the foot of the south slope, to afford additional security to the light-house, and to prevent the stones from the fore-shore being carried over to the north side.

From the time of its commencement in August, 1812, until the 31st of March, 1841, there had been deposited upon this work 3,369,261 tons of stone.

Cost.—The expenditure upon the whole work, when completed, will, it is estimated, be within one million and a half sterling. The main body of the work is composed of blocks of limestone from the quarries of Oreston, adjoining the harbour of Catwater. They were deposited from vessels constructed for the purpose. In certain portions of the work the blocks have been subsequently ranged from a diving bell. The buttress and the works now in progress round the west end are composed of granite masonry, dovetailed horizontally, and fixed vertically by iron levis cramps.

Subsequently to the reception of the plan of Messrs. Rennie and Whidby, most of the leading engineers of the day were consulted, under whose directions the author has superintended the execution of the work.

The communication is accompanied by six elaborate drawings by Mr. Dobson, illustrating in detail the various stages of the work, and the mode of construction.

Mr. Rendel could have wished that the account of this interesting work, the most extensive of the kind in Great Britain, had entered more fully into details, not only of the difficulties met with and overcome, but of the peculiarities of the construction; there were many points connected with it of great importance to engineers. He would allude to one only upon which no information was given; the amount of interstice in the whole cubic content as compared with the mass of materials employed; an accurate account had been kept of the quantity of stone deposited, and knowing the cube of the mass at a given period, he had ascertained the amount of interstice or vacant space in the old part of the works to be at one time 37 per cent. This great deficiency of solidity had arisen from the employment of an excess of large stone, or rather from a deficiency of small stone to fill the interstices between the large stones.

June 22.—The PRESIDENT in the Chair.

The following were elected: Joseph Colthurst, as a Graduate; Colonel George Ritso Jervis, B. E., Captain Henry Goodwyn, B. E., and William Lamb Arrowsmith, as Associates.

"*On the Construction and Use of Geological Models in connexion with Civil Engineering.*" By Thomas Sopwith, F. G. S., M. Inst. C. E.

The author commences this paper with a review of the various methods adopted for the representation of objects required in carrying out the designs of engineers, architects, and mechanics—whether as the means whereby such designs are first studied, and afterwards matured—as guides for the resident superintendents and workmen—or for being preserved as records of what has been executed, and studies for those who may be engaged in similar undertakings.

He then proceeds to elucidate the advantages peculiarly possessed by models for demonstrating practical results in Geology and Mining, dividing the subject into six heads, as follows:

1. On the application of modelling to geological and mining purposes.
2. On the materials to be employed.
3. On the mode of construction.
4. On the scales to be employed.
5. On the objects to be represented.
6. On the use of geological models, and the connexion of the subject with civil engineering.

1. A large number of plans and sections is usually required to elucidate with clearness the geology of a district, and the nature and extent of mining operations; and few departments of practical science admit of greater improvement than the art of delineating mining plans in connexion with geological features.

Much ingenuity has been exercised in representing the undulating surface of countries either by the process called "relief-engraving, (procèdé Collas) or as in the Ordnance Maps of England and Wales, and Mr. Greenough's recent edition of his Geological Map; but even in comparison with these a model affords a more correct idea. Hence models in relief are more peculiarly applicable in all cases where it is desirable to comprehend at once the relations of the several parts, and it is evidently still better adapted to explain the geological conditions; especially when it is required to show the relative position of various rocks, their inclination, thickness, extent, and the disturbances to which they have been subjected, which could only be understood by comparing together a number of drawings.

To those interested in mining, therefore, the easiest mode of conveying ideas is by modelling. This was illustrated by two models of the Forest of Dean, and by reference to Mr. Jordan's model of the Dolcoath mine, now in the Museum of Economic Geology.

Materials for models.—2. The first material for forming a model which naturally occurs to the mind is clay, pins and wires being used to define the principal elevations. Plaster of Paris has occasionally been used, and is well adapted for solid forms, where the edges are not exposed to injury; but its brittleness and contraction in drying are objectionable. Papier Mâché is a more elegant and durable material, but the expense of the requisite moulds prevents its general use. Coloured wax is adapted for small models not subject to be handled. Pottery appears to possess more requisites, but many corresponding disadvantages. Of all the materials which the author has employed, he found none so generally useful as well-seasoned wood, whether for the facility with which the requisite forms are attained, for durability, for portraying different strata by various-coloured woods, or for comparative economy.

Mode of construction.—3. The mode of constructing geological models had been briefly alluded to by the author on a preceding occasion.* It is more fully described in the present communication, and was illustrated by complete models, and the detached parts for forming them purposely made on a large scale.

The plan of the district being divided by lines at given distances apart, into a certain number of squares, a series of thin slips of wood are made to intersect each other, corresponding to the lines so drawn—upon these slips the profile of the surface and the positions of the strata are delineated, when it is intended that the model when complete shall be dissected; the compartments are then filled in with wood, and carved down to the lines upon the slips; the several strata thus rest upon the subordinate beds, and can be detached in a mass or in compartments; these being geologically coloured, convey an accurate idea of the relative positions of the strata, and display with the utmost clearness the mining operations in each. This system is applicable to any extent: and the operation of forming the model is so simple, that a skilful workman at once comprehends and executes unerringly the instructions given him by the engineer or surveyor, as the accuracy entirely depends upon the profile which is drawn upon the slips. The author considers lime-tree or plane to be the most suitable wood for the purpose; but in the construction of small models for showing peculiar geological features or disturbances of strata, he uses various coloured woods: as an illustration of which he showed a series of twelve models, which (with a printed description*) are now in the Museum of the Institution. These contain 579 pieces of wood, one of them consisting of 130 pieces. By fitting the parallel layers of wood together, and arranging them in conformity with sections of strata of the carboniferous limestones and coal measures of the north of England, he illustrates the formation of that district, and the nature of its dislocations, &c. better than can be done by any number of plans and sections.

4. *Scales to be employed.*—Attention is drawn at some length to the proportion to be observed between the horizontal and vertical scales, and the relative merits of corresponding and dissimilar horizontal and vertical scales fully examined, illustrating the positions by two models of the Forest of Dean, in one of which the vertical is enlarged to three times that of the horizontal scale; while the other has the scales exactly alike. For the conventional purpose of giving an idea of a country such as would be formed by a general observer passing through it, the former model appeared best adapted; but in a scientific point of view the latter had a decided advantage, being based on geometrical truth, aud conveying an exact knowledge of the real, but not of the apparent relations of the surfaces, and other objects represented.

5. *Objects to be represented.*—Models had hitherto been chiefly used for conveying impressions of tracts of the surfaces of countries, or for displaying the minute tracery and proportions of buildings. The author's views have been more especially directed to introducing the construction of models for geological and mining purposes, for which he considers them peculiarly adapted.

The series of models now presented to the Institution, contains examples of various geological phenomena of regular stratification—interruption by slips, faults, and dykes—the effects of denudations in exposing to view the various strata—the deceptive appearance of the course of mineral veins on the surface—the intersection of veins—and many other details which are intimately connected with practical mining.

6. *Models used in civil engineering.*—The author then proceeds to describe his view of the uses of such models, and the connexion of the subject with civil engineering.

He considers that by them a practical knowledge of geology may be attained by the civil engineer, and that such knowledge is indispensable for his guidance in many of the works he is called upon to undertake in the exercise of his profession. It is to an engineer that the merit is justly due of having, by efficiently labouring to establish English geology on a firm basis, acquired the title of "Father of Geology," which has been generally conceded to the late Mr. William Smith.

The avocations of the civil engineer peculiarly qualify him for an observant geologist; and being called upon to visit so many different districts, the remarks he might make would be replete with instruction. These observations might be illustrated more efficiently by models than by any other means; at the same time they might be made to answer another purpose—that of demonstrating to the owners of mineral property the advantage or the futility of commencing researches or mining speculations.

Plans do not admit of such certainty of definition as modelling, and no regular system of planning mining districts has yet been generally practised, by which the engineer can judge of the probable results of the operations which he is often called upon to direct. As a record of mining operations, models of this kind are pre-eminently valuable; the exact position not only of the mineral veins and the strata are clearly shown, but the quantities extracted are registered, and a guide for future proceedings is established. The author contends that it is a duty to secure, while it is in our power, such records of mining operations as may enable us and our successors really to exhaust whatever minerals can be worked with advantage.

As being in some degree connected with the subject under discussion, Dr. Buckland described a mode used by Sir John Robison, for obtaining moulds for plaster casts. The object, of which the mould was required, was immersed in a mixture of common glue, dissolved in brewers' sweet wort of about the consistency of thick cream, and allowed to remain until the mass became

* Journal, Vol. III., page 347.

* Description of a series of Geological Models, &c. By Thos. Sopwith, F.G.S., &c. 12mo. Newcastle, 1841.