a favorable report. If any of them feels aggrieved at our language, let him say so, and we will prove its literal accuracy."

"The helpless creatures are only human moles. As they burrow in their 'dim galleries,' what can they know of the inner world, which their predecessors only discovered at the moment when communication was interrupted between them and their fellow grubbers?"

"See what will happen at this Detroit meeting: Their Entomological Club will have heated debate upon trapdoor spiders, and acrimoniously discuss whether the male *mygale avicularia* has a darker shade of brown than the female on the upper segment of the body, and more ciliæ to the square inch; after which, as an appetizer for dinner (champagne and fixings on the lake), mention will be made of that Dismal Swamp louse, which (see Trans. 1874) the surveyors found always pointing its nose to the north, whichsoever way they might lay it down. Professor Hilgard will enquire, across the room, of Professor Dawson, whether the Myriapoda with two antennæ, so highly esteemed by the scolopendra tribes of India, are more nutritious than the date palm. Professor Youmans will propose to the Club the election to honorary membership of the "correspondent of the Department of Agriculture" whose discovery of mortality among bots, upon the application of a decoction of tansy he had appropriately noticed at page 384, Vol. VII, No. 39 of *Popular Science Monthly*. Professor E. B. Elliot will show that he was right and Professor H. E. Davis wrong in the number of young *lepidoptera* which, when placed end to end, will measure a mile, —the true figures being 0174 x b—y542½ = A'ss.

"The anthropological subsection will no doubt give prominence to a discussion upon measles as a religious element among the Andamanese; and an adjournment could hardly be reached without a fight over the old puzzle, whether it is probable that the American stovepipe represents the form of the prayer cylinder of the lacustrians. If Professor Buchanan, who has forgotten more about anthropology than any of them ever know, should attempt to crowd upon them the complete study of man in all his relations, he will be coughed down and the floor granted to somebody who has a speech ready upon the reticulated button hole of the Bengalese Rajpoot's coat. And yet they are not happy.

"Have we done any injustice to the American and British Associations—for they are both alike? Consult the printed volumes of *Transactions*, in which may be found a record of some of the very papers above enumerated, and others about orange peel oil, fat women, hyena's dens, and the blastoderms of birds' eggs.

It is their own affair whether they study this or that science, and prefer to use the few hours they have on earth in discovering the nature of the respiratory organs of the shark or any other ignoble tomfoolery, to studying the spiritual part of Man and his intermundane communications, attractions, and perils."

[For the Scientific American.]

THE HEATING SURFACE OF BOILERS.

The questions sent to us in regard to boilers continue to multiply, and we imagine that we have received inquiries on all the points connected with the subject. We propose, therefore, to devote some space to answering these questions more in detail than is possible in our correspondence column; and after disposing of the topic indicated by the title of this article, we will give some directions in regard to setting boilers, proportioning them for engines of given size, etc.

There is some difference of opinion among engineers in regard to what parts of a boiler are to be considered in estimating its heating surface; but in the rules which are appended, the methods most commonly employed are adopted.

(*a*) Cylindrical boilers: These, forming the simplest class of boilers, consist of plain cylinders, sometimes with and sometimes without steam drums. The heating surface of such a boiler is half the surface of the shell, or it is equal to 1·5708 × the diameter of the boiler × the length. It is to be observed that, in this and in the rules that follow, all dimensions are to be taken in feet; so that, in applying the rule, any proportions that are expressed in inches are to be divided by 12, before making the calculation. Thus: Suppose that a given boiler has a diameter of 36 inches and a length of 20 feet: its heating surface is the product of 1·5708, 3, and 20, or about 94¼ square feet.

(*b*) Cylindrical flue boilers: A boiler of this class is a cylinder with two large flues. Its heating surface is half the surface of the shell, increased by the sum of the interior surfaces of the flues, or 1·5708 × diameter of boiler × length + 6·2832 × interior diameter of flues × length.

For the sake of illustrating this rule, suppose that a flue boiler has a diameter of 48 inches or 4 feet, and a length of 22 feet, and that the interior diameter of each flue is 15 inches, or 1¼ feet. Then the heating surface is equal to the product of 1·5708, 4, and 22, or nearly 138¼ square feet, increased by the product of 6·2832, 1·25, and 22, or about 172¾ square feet, making the total heating surface 311 square feet.

(*c*) Cylindrical tubular boilers: As the name implies, these boilers are cylinders containing a number of tubes. To find the heating surface of such a boiler, take half the surface of the shell and add it to the interior surface of the tubes. Expressing this rule in a similar manner to the foregoing, it may be said that the heating surface of a cylindrical tubular boiler is equal to 1·5708 × diameter of boiler × length + 3·1416 × number of tubes × interior diameter of a tube × length.

Example: A cylindrical tubular boiler has a diameter of 42 inches or 3½ feet, is 16 feet long, and contains 40 tubes, each having an interior diameter of 3⅞ inches, or 0·323 feet. What is its heating surface?

Answer: The product of 1·5708 × 3·5 × 16 is nearly 88 square feet.

The product of 3·1416 × 40 × 0·323 × 16 is about 649 square feet.

So that the whole heating surface is 737 square feet.

When the dimensions of a tubular boiler are given, the outside diameter of the tubes is usually stated, so that twice the thickness must be subtracted to obtain the diameter to be used in the calculation. The thickness of tubes by different makers varies somewhat, but those given below are average values, and can generally be used without serious error. The table gives dimensions of standard sizes of tubes, as well as a column of heating surface, which will greatly facilitate calculations.

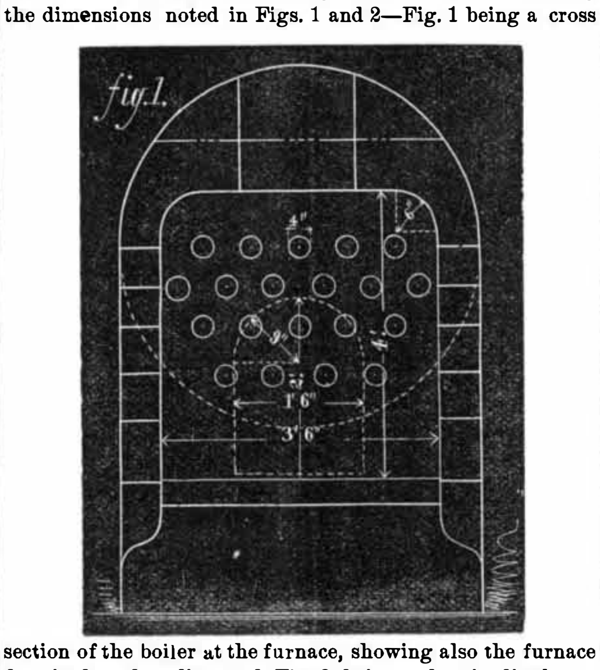
Outside diameter in inches.	Thickness in inches.	Internal diameter in inches.	Internal diameter in feet.	Heating surface in in square feet, per foot of length.
1 25	0·072	1·106	0 0922	0·3273
1 5	0·083	1·334	0·1112	0·3926
1·75	0 095	1·560	0·1300	0·4589
2·	0 095	1·810	0 1508	0 5236
2·25	0·095	2 060	0·1717	0·5890
2·5	0·109	2 282	0·1902	0 6545
2·75	0·109	2 532	0·2110	0·7200
3·	0·109	2·782	0 2318	0·7853
3·25	0 120	3 010	0 2508	0 8508
3·5	0 120	3·260	0·2717	0·9163
3·75	0·120	3·510	0·2925	0·9817
4·	0·134	3·732	0 3110	1·0472
4·5	0·134	4·232	0·3527	1·1790
5·	0·148	4·704	0 3920	1·3680
6·	0·165	5·770	0 4808	1·5708
7·	0·165	6·770	0 5642	1·8326
8·	0·165	7·770	0·6475	2·0944
9·	0·180	8·640	0·7200	2 3562
10·	0·203	9·594	0·7995	2·5347

To illustrate the use of the table, suppose it is required to find the heating surface of the tubes in a boiler which contains 60 tubes, each 3 inches outside diameter and 12 feet long. The total length of tubes in the boiler is 12 times 60, or 720 feet, so that the heating surface is 720 times 0·7853, or about 565 square feet.

(*d*). Locomotive and vertical boilers: In this class, the furnaces are contained within the boilers. The heating surface of such a boiler is all the surface in the furnace increased by the interior surface of the tubes.

Locomotive boilers: The furnaces of boilers of this class do not all have the same form of cross section, so that the rule for determining the heating surface cannot be, generally, expressed precisely in detail. It may be said, however, that the heating surface of a locomotive boiler is equal to the length of the line bounding the cross section of the furnace × the length of the furnace + 2 × the area of the cross section of the furnace — the area of the furnace door — the number of tubes × 0·7854 × (the interior diameter of a tube)^2 + the number of tubes × the length of the tubes × the heating surface of a tube per running foot.

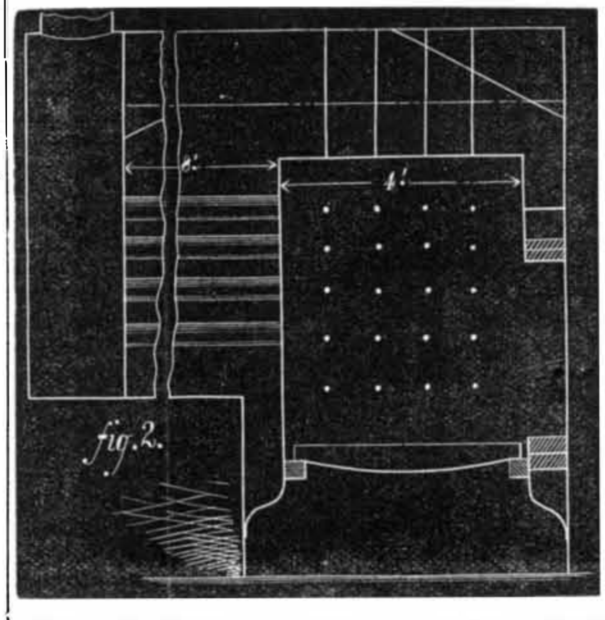
As an example of the use of this rule, suppose it is required to determine the heating surface of a boiler having the dimensions noted in Figs. 1 and 2—Fig. 1 being a cross



section of the boiler at the furnace, showing also the furnace door in dotted outline, and Fig. 2 being a longitudinal section. The length of the line bounding the cross section of the furnace is the sum of 3·5 × 2 + 2·5 + 1 multiplied by 1·5708, or about 11·07 feet. The area of the sides and top of the furnace is 4 times 11·07, or 44·28 square feet. The area of the cross section of the furnace is the sum of the products of 3·5 × 3·5 + 0·5 × 2·5 + 0·5 × 0·7854, or about 13·89 square feet. The cross section of the tubes is the product of 20 × 0·7854 × (0·311)^2, or about 1·52 square feet. The area of the furnace door is the sum of the products of 1·5 × 1·25 + 0·3927 × (1·5)^2, or about 2·76 square feet. The interior surface of the tubes is the product of 20 × 8 × 1·0472, or about 167·55 square feet. Hence the heating surface of the boiler is 44·28 + 2 × 13·89 — 1·52 — 2·76 + 167·55, or about 235½ square feet. This example shows the general method to be employed for locomotive boilers, and the dimensions that are to be taken.

2. Vertical boilers: The furnaces of these boilers are ordinarily cylindrical, so that the rule for the heating surface is as follows: 3·1416 × diameter of furnace × hight of furnace + 0·7854 × (diameter of furnace)^2 — number of tubes × 0·7854 × (interior diameter of a tube)^2 + number of tubes × length of tubes × heating surface of a tube per running foot.

Example: Required the heating surface of a vertical boiler, having the following dimensions: Diameter of furnace, 24 inches, hight of furnace, 18 inches, 40 tubes, each 2 inches outside diameter, 6 feet long. The heating surface is the sum of the products of 3·1416 × 2 × 1·5 + 0·7854 × 2^2 + 40 × 6 × 0·5236 = 138·23, diminished by 40 × 0·7854 × (0·1508)^2 = 0·72, or 137·51 square feet.



These rules might be extended, so as to include sectional and marine boilers, together with some special forms which are occasionally used: but it is believed that they are sufficiently comprehensive to apply to nearly all boilers employed in this country for stationary and portable engines. The simple manner in which they are expressed, and the illustrative examples accompanying them, will doubtless be appreciated by the reader.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The meeting this year is a light one in point of attendance; but the lack in this respect is in a measure compensated for by the absence of ponderously technical papers and the substitution of essays having a more practical bearing upon the scientific questions of the day. While a cardinal object of this association is the interchange of ideas of all kinds among its learned members, the nature of such interchanges should, we think, be subordinated to considerations of public instruction and benefit, and hence dissertations on abstruse points and technicalities unintelligible to all save those versed in the particular branch of Science involved, might well be reserved for dissemination through narrower channels, leaving a clear field for the discussion of subjects within the general public comprehension. It is impossible to publish such papers in their entirety, and equally impossible to prepare fairly intelligible abstracts. We give below a *resumé* of the essays thus far read.

Professor Lovering described an acoustic method of measuring the velocity of electricity. He stated that a wire from Cambridge to San Francisco, thence back through Canada to Massachusetts, about 7,200 miles in all, transmitted a message in two thirds of a second, and that some of this time was wasted through thirteen repeaters. The system proposed consisted in utilizing the vibrations of tuning forks, which may indicate intervals of one ten-thousandth of a second, or even less.

Professor Farquharson read an account of recent

EXPLORATIONS AMONG INDIAN MOUNDS,

which resulted in the discovery of thirty skeletons, several copper implements, and a pulley or spindle wheel of terra cotta. In one skeleton two of the neck bones were found anchylosed, giving evidence of a disease rare at the present time among adults, and from which they only survive by very careful treatment.

Professor E. B. Andrews compared the Ohio and Virginia sides of

THE GREAT ALLEGHANY COAL FIELD.

On the Kanawha there are 3,100 feet of productive coal measures below the horizon of the Pittsburgh coal. The remarkable belt of coal seams found on the Kanawha, between Charleston and Kanawha, on Coal river, on the Guyandotte, and on the upper waters of the Twelve Pole, and on the Tag and Louisa forks of the Big Sandy, is the finest belt of bituminous coal in the United States. The professor traced the probable direction of the great West Virginia geosynclinal trough, and expressed the opinion that it had a connection with the ancient ocean to the southwest by the way of Tennessee.

Professor J. S. Newberry gave descriptions of some newly discovered

ANCIENT FISHES

found in the Devonian and carboniferous rocks of Ohio. Among these was the entire bony structure of the *dinichthys Terellii*, the hugest of all the old armor-plated ganoids. The dorsal shield weighed 30 pounds. Drawings of another species of *dinichthys* were shown, in which the maxillaries and mandibles were set with teeth instead of being sharp-edged. Professor Newberry explained that the *dipnoans* of Africa and South America, the *lepidosiren* and *protopterus*, were descended from these ancient plated ganoids, and were the last remnants of a group of fishes which in the Devonian age not