PART XI

MENSURATION, APPLIED TO SHEET METAL WORK

A REQUIREMENT of the times is that the sheet metal pattern draftsman be not alone proficient in the art and science of developments, but that he understand the uses of mensuration applied in the solution of problems of sheet metal work. As a preparatory step to the development of such articles as transition pieces for heating, ventilation, blower and exhaust work, the sizes and areas of outlets must be determined and it is therefore essential that the pattern cutter be qualified to employ the rules of mensuration for finding areas, capacities, and unknown sizes. The present chapter relates to the science of mensuration with respect only to its application to the actual problems of sheet metal work occurring in the daily practice.

Attention is directed to the method of utilizing the steel square as a rapid calculator, as well as to the convenient uses of tables of areas and circumferences. These are phases of the subject worthy of a more general appreciation among mechanics. These simple yet widely applicable rules of mensuration will render superfluous much of the laborious figuring frequently expended in finding areas and the sizes of pipe and fittings.

FINDING THE CIRCUMFERENCE, CONVEX SURFACE, AREA AND CAPACITY OF A ROUND TANK

Solution 204

Fig. 663 shows a round tank of given dimensions, of which we will obtain the circumference, convex surface, area and capacity. The rules to follow in finding the four results should be carefully considered as they apply to any size or hight of circle.

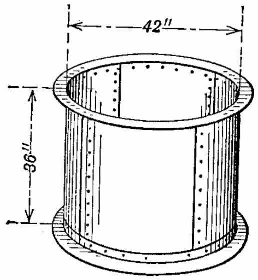

Fig. 663.—Finding Circumference, Convex Surface Area and Capacity of Round Tank

The Circumference

Multiply the diameter by 3.1416; thus $42 \times 3.1416 = 131.9472$, or the practical equivalent of 132 in. However, if the fraction is sought to equal the smallest fraction on the two foot rule, which is 16, then, in all cases, multiply the remaining decimal fraction by 16, as follows: $.9472 \times 16 = 15.1552$. As .9472 contains four figures, step off four figures to the left of 15.1552, as shown, resulting in 15 or 15/16. The correct answer to 131.9472 is 131 15/16 in. The rule applies to any diameter of round pipe.

Convex Surface

To find the convex surface of the tank or to compute the amount of material to make up the body, simply multiply the circumference by the hight thus: $132 \times 36 = 4752$, the number of square inches, without laps. The number of square feet may be obtained by dividing 4752 by 144 (the number of square inches in a square foot) thus:

$$\frac{4752}{144} = 33 \text{ sq. ft.}$$

Area

The tank has a diameter of 42 in. as indicated in Fig. 663. Its area is found by squaring the diameter and multiplying by the decimal .7854. Thus, $42^2 \times .7854 = 42 \times 42 \times .7854$, or $42 \times 42 = 1764$. $1764 \times .7854 = 1385.4456$.

Capacity

Having thus found the area of a 42 in. circle to be 1385.4456, let us proceed to obtain the capacity of a tank of 42 in. diameter and 36 in. hight by multiplying its area, thus: $1385.4456 \times 36 = 49876.0416$, the capacity in cubic inches. This sum divided by 231 (the number of cubic inches in a gallon) results as follows: $\frac{49876.0416}{231} = 215+$; or a close approximate of 216 gallons.

The rule applies to computing the capacities of all tanks having vertical sides and round bottoms.

FINDING HEIGHT OF ROUND TANK OF GIVEN DIAMETER AND CONTENTS IN GALLONS

Solution 205

Let us assume that an order comes to the shop for a round tank, as shown in Fig. 663, whose required diameter is 42 in. and capacity 216 gallons. What is the required height of the vertical sides? The rule to employ is that of reducing the number of gallons to cubic inches and dividing the quotient by the area of the 42 in. circle. Thus 216 gallons multiplied by 231 cubic inches = 49896 cubic inches. Since the area of the 42 in. circle equals 1385.4456 square inches, we omit the decimal and divide 49896 by 1385 when the quotient is 36 in., the height of the tank.

FINDING THE PERIMETER, OUTER SURFACE, AREA AND CAPACITY OF A SQUARE TANK

Solution 206

Fig. 664 presents a view of a square tank of given dimensions, of which we will find the amount of

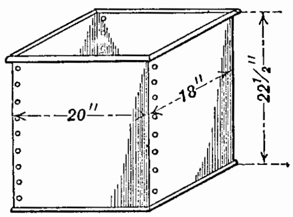

Fig. 664.— Finding Perimeter, Area and Capacity of Square Tank

stock required, as well as the area and capacity of the tank.

Perimeter

To find the perimeter of the square tank or its girth around the body, simply add thus: $20 + 18 + 20 + 18$ or 76 in., without laps.

Outside Surface

The outer surface of the tank is found by multiplying the perimeter of 76 in. by the vertical height of 22½ in. Thus $76 \times 22.5 = 1710$ square in. Divide this sum by 144, the number of sq. inches to the sq. ft., when the quotient of 11 sq. ft. + or almost 12 sq. ft. will be the required surface.

Area

To find the area, simply multiply one side by the other. Thus $18 \times 20 = 360$ sq. in. area.

Capacity

The capacity, or solid contents, is found by multiplying the area by the height. Thus $360 \times 22.5 = 8100$ cubic inches. Divide this product by 231, the number of cubic inches in a gallon, thus: $\frac{8100}{231} = 35 +$ gallons.

The four foregoing rules are applicable in computing all square or rectangular tanks.

ASCERTAINING THE HEIGHT OF A SQUARE TANK OF GIVEN BOTTOM DIMENSIONS AND CONTENTS IN GALLONS

Solution 207

What is the required height for a 35 gallon tank whose bottom measures 18 x 20 in.? Reduce the number of gallons to cubic inches, and divide the product by the area of the bottom, thus: $231 \times 35 = 8085 \div 360 = 22.5$. Therefore the required height of the sides is 22½ in. This rule has application to any size of square or rectangular tank.

FINDING AREA, CAPACITY, AND CONVEX SURFACE OF A SQUARE TAPERING GRAIN HOPPER

Solution 208

Fig. 665 illustrates a square tapering grain hopper, with indicated dimensions from which we will

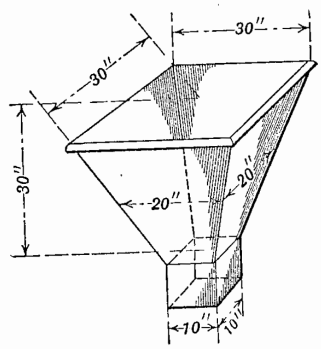

Fig. 665.— Finding Area, Capacity and Convex Surface of Grain Hopper

compute the area, the capacity in bushels, as well as the material required for purposes of construction.

Area

First determine the areas of the top and bottom sections and a section taken midway between top and bottom. As the size of the top is 30 x 30 its area is 900. The bottom area is 10 x 10 or 100. To compute the middle section, add the top and bottom dimensions and divide by two. Thus, $\frac{30 + 10}{2} = \frac{40}{2} = 20$. The middle section then measures 20 x 20 and its area is 400.

Capacity

The rule for finding the contents of the hopper is as follows: Add the areas of the two parallel planes (top and bottom) and four times the area of the middle plane. Multiply the sum by one-sixth the vertical hight. The upper plane has an area of 900, the lower plane an area of 100 and four times the middle plane an area of 1600. Then $900 + 100 + 1600 = 2600$. As the vertical hight is 30 in., one sixth equals 5 in. Now, multiply the combined areas, or $2600 \times 5 = 13000$ cubic inches, the capacity. The next step is to ascertain the cubic inches per bushel. By reference to a table of dry or cubic measure, we find that a standard bushel contains 2150.42 cubic inches. Divide 13000 by 2150.42 thus: $\frac{13000}{2150.42} = 6$ bushels, plus 97.48 cubic inches, or 6 + bushels.

Convex Surface

Proceeding to find the convex surface of the hopper, or the amount of material required in its construction, the following quick method may be used to obtain the girth, without either the aid of computation or the preparation of a drawing. Use the steel square, setting the rule from 30 in., the vertical hight, on one leg of the square to 10 in., the amount of pitch, on the other. This distance measures 31⅝ in. This example may also be computed as follows: $\sqrt{30^2 + 10^2} = 31.62$, or 31⅝ in. Add allowance of ¾ in. for wire and ⅛ in. for a single seam at the lower edge, making the total girth 32.5 in. Now add the narrow end 10 to the wide end 30 and divide by 2, thus: $\frac{10 + 30}{2} = 20$. Then $20 \times 32.5 = 650$ sq. in. for one side and $4 \times 650 = 2600$ sq. in. convex surface for the four sides. Divide 2600 by 144 to obtain the square feet. Thus, $\frac{2600}{144} = 18 +$ sq. feet.

ASCERTAINING HEIGHT OF A TAPERING SQUARE HOPPER OF GIVEN DIMENSIONS AND CONTENTS IN BUSHELS

Solution 209

What is the required hight of a hopper whose top dimension is 30 x 30 in., bottom dimension 10 x 10 in., and whose capacity is six bushels? The following rule is applicable to all computations of this nature. The combined area of the top, bottom and four times the middle section equals 2600 as previously ascertained and since there are 2150.42 cubic inches in a bushel we multiply that number by 6, with the result of 12902.52 cubic inches, into which divide the combined areas thus: $\frac{12902.52}{2600} =$ 5, less 97.48 cubic inches. The approximate number 5 may be used for all practical purposes. Now, multiply 5 by 6, thus obtaining 30 in. as the vertical hight. 6 is used always as the multiplier, with regard to given dimensions.

FINDING AREA, CAPACITY, AND CONVEX SURFACE OF A ROUND TAPERING TANK

Solution 210

Fig. 666 illustrates a round tapering tank having an indicated top diameter of 20 in., a bottom diameter of 40 in., and vertical hight of 36 in. How many gallons will this tank hold? The following rules readily apply to all computations for round tapering tanks of various dimensions.

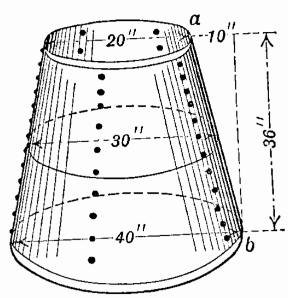

Fig. 666.—Finding Area, Capacity, and Convex Surface of Tank

Area

It is not practicable to compute the capacity of round tapering tanks until the top and bottom areas are ascertained as well as that of the section midway between top and bottom. The method, which is alike to that previously explained, is as follows: Since the diameter of the top is 20 in., we have as the area, $20 \times 20 \times .7854 = 314.16$ sq. in. The area of the bottom is equivalent to $40 \times 40 \times .7854$ or 1256.64 sq. in. The diameter of the section taken midway between top and bottom is figured thus: $\frac{20 + 40}{2} = \frac{60}{2} = 30$ in. Therefore, $30 \times 30 \times .7854 = 706.86$ sq. in. area of the 30 in. diameter.

Capacity

The rule for finding the capacity of the tank is as follows: Add the areas of the top and bottom diameters, plus four times the area of the middle section and multiply the sum by one sixth the vertical hight. This gives the total cubic inches. The result is divided by 231 (the number of cubic inches per gallon), and the product is the capacity in gallons. In computing the area, we found that of the top diameter to be 314.16, the bottom area 1256.64 and four times the area of the middle section, 2827.44. Therefore, we compute, $314.16 + 1256.64 + 2827.44 = 4398.24$, and $4398.24 \times 6 = 26389.44$ cubic inches. Thus, the capacity is $\frac{26389.44}{231} =$ 114.24 gallons. Thus, a tank of these dimensions will contain 114¼ gallons.

Convex Surface

To find the convex surface or the amount of material required to make up the curved surface of the tank, the following rule is employed: Construct a right angle whose base is 36 in. and whose altitude is 10 in. Then will the slant distance *a* to *b* in Fig. 666 measure 37⅜ in. If this hypothenuse were computed for exact results, the computation would be as follows: $\sqrt{36^2 + 10^2} = 37.363$ in. By the use of the steel square we obtain 37.375, a slight fractional excess sufficiently near for any practical requirement. To the slant length *a b* of 37⅜ in., add ¼ in. for a single double seaming edge at the bottom and 1⅜ in. girth for ½ in. thick wire at the top, making the total stock measurement of the slant *a b* 39 in. Now multiply the sum of the circumferences of the two ends by one half the slant hight thus: $20 \times 3.1416 = 62.8320 + 40 \times 3.1416 = 125.6640$. The sum equals $188.496 \times 19.5 = 3675.672$ sq. in. Divide this amount by 144 (sq. in. per sq. ft.) obtaining $\frac{3675.672}{144} = 25.5$ or 25½ sq. ft. of surface.

FINDING THE HEIGHT OF A TAPERING ROUND MEASURE WHEN THE DIAMETERS AND NUMBER OF GALLONS ARE GIVEN

Solution 211

We will assume that a three gallon copper measure is to be made with top diameter of 7 in. and bottom diameter of 11½ in. What is the required height of the measure? The rule applicable to obtaining any size of tapering vessel is as follows: Find the number of cubic inches in the given capacity which divide by the sum of the areas of the top and bottom diameters plus four times the area of the middle section and multiply the quotient by 6. Three gallons contain 3×231 cubic inches. The present measure will then contain 693 cubic inches. As the diameter of the top is 7 in., its area is $7 \times 7 \times .7854$ or 38.4846 sq. in. The area of the bottom diameter is $11.5 \times 11.5 \times .7854 = 103.869$, and the area of the middle section is $\frac{7 + 11.5}{2} = \frac{18.5}{2} = 9.25$. Thus, $9.25 \times 9.25 \times .7854 = 67.2008$. Four times this area is $4 \times 67.2008 = 268.8032$. Then $38.4846 + 103.869 + 268.8032 = 411.1568$. Now, divide the 693 cubic inches by 411.1568 and the quotient will be 1.685. Six times $1.685 = 10.11$ inches the required height or the approximate of 10⅛ inches.

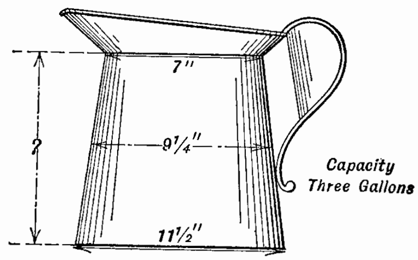

Fig. 667.— Finding the Height in a Flaring Measure

Uses of Table of Circumference and Areas of Circles

A table of areas and circumferences is a practical necessity for reference purposes, saving as it does much of the time and labor of computation. The circumference table presented herewith advances from diameters of 1/64 in. to 100 in., graduating by ⅛ in. The following examples clearly show the convenient and essential uses of the tables indicating how they are employed in calculating the requirements of heating, ventilation and blower work.

CIRCUMFERENCES AND AREAS OF CIRCLES FROM 1-64 TO 100 INCHES

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
1/64	.0491	.0002	9 3/4	30.6306	74.6621	31 1/4	98.1750	766.992	56 1/2	177.500	2,507.19
1/32	.0982	.0008	9 7/8	31.0233	76.589	31 1/2	98.9604	779.313	57	179.071	2,551.76
1/16	.1963	.0031	10	31.4160	78.540	31 3/4	99.7458	791.732	57 1/2	180.642	2,596.73
1/8	.3927	.0123	10 1/4	32.2014	82.516	32	100.5312	804.250	58	182.213	2,642.09
3/16	.5890	.0276	10 1/2	32.9868	86.590	32 1/4	101.3166	816.865	58 1/2	183.784	2,687.84
1/4	.7854	.0491	10 3/4	33.7722	90.763	32 1/2	102.1020	829.579	59	185.354	2,733.98
5/16	.9817	.0767	11	34.5576	95.033	32 3/4	102.8874	842.391	59 1/2	186.925	2,780.51
3/8	1.1781	.1104	11 1/4	35.3430	99.402	33	103.673	855.301	60	188.496	2,827.44
7/16	1.3744	.1503	11 1/2	36.1284	103.869	33 1/4	104.458	868.309	60 1/2	190.067	2,874.76
1/2	1.5708	.1963	11 3/4	36.9138	108.434	33 1/2	105.244	881.415	61	191.638	2,922.47
9/16	1.7671	.2485	12	37.6992	113.098	33 3/4	106.029	894.620	61 1/2	193.208	2,970.58
5/8	1.9635	.3068	12 1/4	38.4846	117.859	34	106.814	907.922	62	194.779	3,019.08
11/16	2.1598	.3712	12 1/2	39.2700	122.719	34 1/4	107.600	921.323	62 1/2	196.350	3,067.97
3/4	2.3562	.4418	12 3/4	40.0554	127.677	34 1/2	108.385	934.822	63	197.921	3,117.25
13/16	2.5525	.5185	13	40.8408	132.733	34 3/4	109.171	948.420	63 1/2	199.492	3,166.93
7/8	2.7489	.6013	13 1/4	41.6262	137.887	35	109.956	962.115	64	201.062	3,217.00
15/16	2.9452	.6903	13 1/2	42.4116	143.139	35 1/4	110.741	975.909	64 1/2	202.633	3,267.46
1	3.1416	.7854	13 3/4	43.1970	148.490	35 1/2	111.527	989.800	65	204.204	3,318.31
1 1/8	3.5343	.9940	14	43.9824	153.938	35 3/4	112.312	1,003.790	65 1/2	205.775	3,369.56
1 1/4	3.9270	1.2272	14 1/4	44.7678	159.485	36	113.098	1,017.878	66	207.346	3,421.20
1 3/8	4.3197	1.4849	14 1/2	45.5532	165.130	36 1/4	113.883	1,032.065	66 1/2	208.916	3,473.24
1 1/2	4.7124	1.7671	14 3/4	46.3386	170.874	36 1/2	114.668	1,046.349	67	210.487	3,525.66
1 5/8	5.1051	2.0739	15	47.1240	176.715	36 3/4	115.454	1,060.732	67 1/2	212.058	3,578.48
1 3/4	5.4978	2.4053	15 1/4	47.9094	182.655	37	116.239	1,075.213	68	213,629	3,631.69
1 7/8	5.8905	2.7612	15 1/2	48.6948	188.692	37 1/4	117.025	1,089.792	68 1/2	215.200	3,685.29
2	6.2832	3.1416	15 3/4	49.4802	194.828	37 1/2	117.810	1,104.469	69	216.770	3,739.29
2 1/8	6.6759	3.5466	16	50.2656	201.062	37 3/4	118.595	1,119.244	69 1/2	218.341	3,793.68
2 1/4	7.0686	3.9761	16 1/4	51.0510	207.395	38	119.381	1,134.118	70	219.912	3,848.46
2 3/8	7.4613	4.4301	16 1/2	51.8364	213.825	38 1/4	120.166	1,149.089	70 1/2	221.483	3,903.63
2 1/2	7.8540	4.9087	16 3/4	52.6218	220.354	38 1/2	120.952	1,164.159	71	223.054	3,959.20
2 5/8	8.2467	5.4119	17	53.4072	226.981	38 3/4	121.737	1,179.327	71 1/2	224.624	4,015.16
2 3/4	8.6394	5.9396	17 1/4	54.1926	233.706	39	122.522	1,194.593	72	226.195	4,071.51
2 7/8	9.0321	6.4918	17 1/2	54.9780	240.529	39 1/4	123.308	1,209.958	72 1/2	227.766	4,128.26
3	9.4248	7.0686	17 3/4	55.7634	247.450	39 1/2	124.093	1,225.420	73	229.337	4,185.40
3 1/8	9.8175	7.6699	18	56.5488	254.470	39 3/4	124.879	1,240.981	73 1/2	230.908	4,242.93
3 1/4	10.2102	8.2958	18 1/4	57.3342	261.587	40	125.664	1,256.640	74	232.478	4,300.85
3 3/8	10.6029	8.9462	18 1/2	58.1196	268.803	40 1/4	126.449	1,272.400	74 1/2	234.049	4,359.17
3 1/2	10.9956	9.6211	18 3/4	58.9050	276.117	40 1/2	127.235	1,288.250	75	235.620	4,417.87
3 5/8	11.3883	10.3206	19	59.6904	283.529	40 3/4	128.020	1,304.210	75 1/2	237.191	4,476.98
3 3/4	11.7810	11.0447	19 1/4	60.4758	291.040	41	128.806	1,320.260	76	238.762	4,536.47
3 7/8	12.1737	11.7933	19 1/2	61.2612	298.648	41 1/4	129.591	1,336.410	76 1/2	240.332	4,596.36
4	12.5664	12.5664	19 3/4	62.0466	306.355	41 1/2	130.376	1,352.660	77	241.903	4,656.64
4 1/8	12.9591	13.3641	20	62.8320	314.160	41 3/4	131.162	1,369.000	77 1/2	243.474	4,717.31
4 1/4	13.3518	14.1863	20 1/4	63.6174	322.063	42	131.947	1,385.45	78	245.045	4,778.37
4 3/8	13.7445	15.0330	20 1/2	64.4028	330.064	42 1/4	132.733	1,401.99	78 1/2	246.610	4,839.83
4 1/2	14.1372	15.9043	20 3/4	65.1882	338.164	42 1/2	133.518	1,418.63	79	248.186	4,901.68
4 5/8	14.5299	16.8002	21	65.9736	346.361	42 3/4	134.303	1,435.37	79 1/2	249.757	4,963.92
4 3/4	14.9226	17.7206	21 1/4	66.7590	354.657	43	135.089	1,452.20	80	251.328	5,026.56
4 7/8	15.3153	18.6555	21 1/2	67.5444	363.051	43 1/4	135.874	1,469.14	80 1/2	252.899	5,089.59
5	15.7080	19.6350	21 3/4	68.3298	371.543	43 1/2	136.660	1,486.17	81	254.470	5,153.01
5 1/8	16.1007	20.6290	22	69.1152	380.134	43 3/4	137.445	1,503.30	81 1/2	256.040	5,216.82
5 1/4	16.4934	21.6476	22 1/4	69.9006	388.822	44	138.230	1,520.53	82	257.611	5,281.03
5 3/8	16.8861	22.6907	22 1/2	70.6860	397.609	44 1/4	139.016	1,537.86	82 1/2	259.182	5,345.63
5 1/2	17.2788	23.7583	22 3/4	71.4714	406.494	44 1/2	139.801	1,555.29	83	260.753	5,410.62
5 5/8	17.6715	24.8505	23	72.2568	415.477	44 3/4	140.587	1,572.81	83 1/2	262.324	5,476.01
5 3/4	18.0642	25.9673	23 1/4	73.0422	424.558	45	141.372	1,590.43	84	263.894	5,541.78
5 7/8	18.4569	27.1086	23 1/2	73.8276	433.737	45 1/4	142.157	1,608.16	84 1/2	265.465	5,607.95
6	18.8496	28.2744	23 3/4	74.6130	443.015	45 1/2	142.943	1,625.97	85	267.036	5,674.51
6 1/8	19.2423	29.4648	24	75.3984	452.390	45 3/4	143.728	1,643.89	85 1/2	268.607	5,741.47
6 1/4	19.6350	30.6797	24 1/4	76.1838	461.864	46	144.514	1,661.91	86	270.178	5,808.82
6 3/8	20.0277	31.9191	24 1/2	76.9692	471.436	46 1/4	145.299	1,680.02	86 1/2	271.748	5,876.56
6 1/2	20.4204	33.1831	24 3/4	77.7546	481.107	46 1/2	146.084	1,698.23	87	273.319	5,944.69
6 5/8	20.8131	34.4717	25	78.5400	490.875	46 3/4	146.870	1,716.54	87 1/2	274.890	6,013.22
6 3/4	21.2058	35.7848	25 1/4	79.3254	500.742	47	147.655	1,734.95	88	276.461	6,082.14
6 7/8	21.5985	37.1224	25 1/2	80.1108	510.706	47 1/4	148.441	1,753.45	88 1/2	278.032	6,151.45
7	21.9912	38.4846	25 3/4	80.8962	520.769	47 1/2	149.226	1,772.06	89	279.602	6,221.15
7 1/8	22.3839	39.8713	26	81.6816	530.930	47 3/4	150.011	1,790.76	89 1/2	281.173	6,291.25
7 1/4	22.7766	41.2826	26 1/4	82.4670	541.190	48	150.797	1,809.56	90	282.744	6,361.74
7 3/8	23.1693	42.7184	26 1/2	83.2524	551.547	48 1/4	151.582	1,828.46	90 1/2	284.315	6,432.62
7 1/2	23.5620	44.1787	26 3/4	84.0378	562.003	48 1/2	152.368	1,847.46	91	285.886	6,503.90
7 5/8	23.9547	45.6636	27	84.8232	572.557	48 3/4	153.153	1,866.55	91 1/2	287.456	6,575.56
7 3/4	24.3474	47.1731	27 1/4	85.6086	583.209	49	153.938	1,885.75	92	289.027	6,647.63
7 7/8	24.7401	48.7071	27 1/2	86.3940	593.959	49 1/4	154.724	1,905.04	92 1/2	290.598	6,720.08
8	25.1328	50.2656	27 3/4	87.1794	604.807	49 1/2	155.509	1,924.43	93	292.169	6,792.92
8 1/8	25.5255	51.8487	28	87.9648	615.754	49 3/4	156.295	1,943.91	93 1/2	293.740	6,866.16
8 1/4	25.9182	53.4563	28 1/4	88.7502	626.798	50	157.080	1,963.50	94	295.310	6,939.79
8 3/8	26.3109	55.0884	28 1/2	89.5356	637.941	50 1/2	158.651	2,002.97	94 1/2	296.881	7,013.82
8 1/2	26.7036	56.7451	28 3/4	90.3210	649.182	51	160.222	2,042.83	95	298.452	7,088.24
8 5/8	27.0963	58.4264	29	91.1064	660.521	51 1/2	161.792	2,083.08	95 1/2	300.023	7,163.04
8 3/4	27.4890	60.1322	29 1/4	91.8918	671.959	52	163.363	2,123.72	96	301.594	7,238.25
8 7/8	27.8817	61.8625	29 1/2	92.6772	683.494	52 1/2	164.934	2,164.76	96 1/2	303.164	7,313.84
9	28.2744	63.6174	29 3/4	93.4626	695.128	53	166.505	2,206.19	97	304.735	7,389.83
9 1/8	28.6671	65.3968	30	94.2480	706.860	53 1/2	168.076	2,248.01	97 1/2	306.306	7,466.21
9 1/4	29.0598	67.2008	30 1/4	95.0334	718.690	54	169.646	2,290.23	98	307.877	7,542.98
9 3/8	29.4525	69.0293	30 1/2	95.8188	730.618	54 1/2	171.217	2,332.83	98 1/2	309.448	7,620.15
9 1/2	29.8452	70.8823	30 3/4	96.6042	742.645	55	172.788	2,375.83	99	311.018	7,697.71
9 5/8	30.2379	72.7599	31	97.3896	754.769	55 1/2	174.359	2,419.23	99 1/2	312.589	7,775.66
						56	175.930	2,463.01	100	314.160	7,854.00

FINDING DIMENSIONS OF RECTANGULAR PIPE, OF EQUAL AREA TO GIVEN ROUND PIPE

Solution 212

Fig. 668 is a view of an offset boot used in warm air heating installation. The indicated dimension of

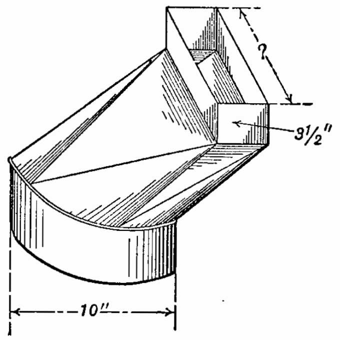

Fig. 668.— Finding the Length of a Rectangular Pipe to Equal the Area of a Given Round Pipe

the round pipe connecting to the furnace is 10 in., as shown, and the width of the rectangular riser, 3½ in. What must be the length of the rectangular pipe in order that its dimension equal the area of the 10 in. round pipe? Consulting the table of Areas, we find that a pipe of 10 in. diameter has an area of 78.540 sq. in. The width of the rectangular pipe is given as 3.5. Therefore divide 78.540 by 3.5 thus, $\frac{78.540}{3.5} = 22.44$ or 22½ in. Thus, the size of rectangular riser of equal area to the 10 in. round pipe is found to be 3½ x 22½ in.

FINDING DIAMETER OF MAIN PIPE OF EQUAL AREA TO THREE BRANCHES

Solution 213

Fig. 669 shows a three pronged fork whose diameters are 6, 7 and 8 in. Let us find the size of

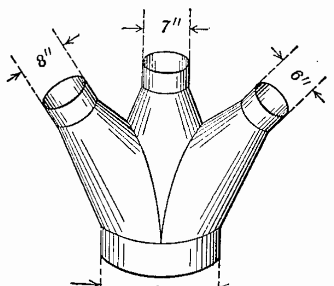

Fig. 669.— Finding the Diameter of the Main Pipe, to Equal the Combined Area of Three Branches

main pipe to have the combined area of the three branches. Reference to the table of Areas saves considerable calculation. The area of a 6 in. pipe is found to be 28.2744; that of a 7 in. pipe, 38.4846, and of an 8 in. pipe, 50.2656. Adding the three areas we obtain 117.0246. Now follow the column of areas in the table to the nearest number, which is 117.859, the area of the pipe is 12¼ in. diameter. Thus 12¼ in. is found to be the required size of main pipe.

FINDING DIMENSIONS OF RECTANGULAR PIPE OF AREA EQUAL TO THAT OF TWO ROUND BRANCHES

Solution 214

The two prongs of the fork shown in Fig. 670 have indicated diameters of 8 and 12 in. What

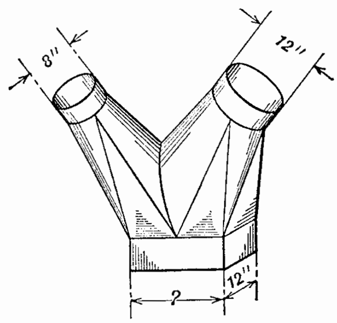

Fig. 670.— Finding the Length of a Rectangular Pipe to Equal the Area of Two Round Branches

must be the length of the rectangular main pipe if its given width is 12 in.? The area of an 8 in. circle is 50.265 plus the area of a 12 in. circle 113.098 is the sum of 163.363. Since the given width of the rectangular pipe is 12 in., we compute thus: $\frac{163.363}{12} = 13.613$ or 13⅝ in. Thus the required size of main pipe to combine the areas of the 8 and 12 in. branches, is 12 in. x 13⅝ in.

FINDING SIZE OF A SQUARE PIPE HAVING AREA EQUAL TO THAT OF TWO ROUND BRANCHES

Solution 215

A two branched fork having indicated diameters of 16 and 17½ in. is shown in Fig. 671. Should the size of a *square* pipe whose area will equal the combined area of the two branches be sought, turn to the table of Areas and find that of the 16 in. circle as 201.062 and that of a 17½ in. circle as 240.529, making a total of 441.591 sq. in. To find the size of the square main, simply extract the square root, thus: $\sqrt{441} = 21$. The required size of the square main pipe is thus indicated as 21 x 21 inches.

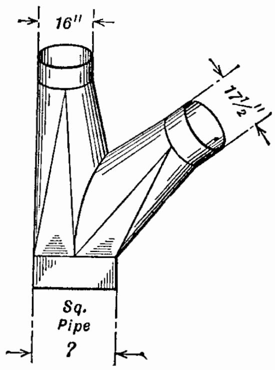

Fig. 671.—Finding the Size of a Square Pipe to Equal the Area of Two Round Branches

This is scant, being one half square inch less than the combined areas of the 16 and 17½ in. branches. So seldom is the extraction of the square root resorted to it is possible the following explanation of the method may be of assistance to some of our readers.

Extracting the Square Root

As a simple illustration, the square root of 4 is 2, since $2 \times 2 = 4$. In like manner the square root of 49 is 7, since $7 \times 7 = 49$. Thus the product of any number multiplied by itself is its square, and the square root is the number thus multiplied. In the foregoing problem there was involved 441 sq. in. To extract the square root proceed as follows: Point off the number of which the square root is sought into divisions of two figures each, toward the left. Thus, in this case, we get 4'41, showing that the complete part of the square root contains but two figures. The calculations are now made as follows:

Trial Divisor	Correct Divisor	Number	Root
40	41	4'41	(21 *Ans.*
		4	
		41	
		41	

Note that here the greatest number whose square is contained in 4 is 2; therefore 2 becomes the first root of the figure, and $2 \times 2 = 4$. As there is nothing to subtract, bring down the next section 41, which gives the first partial dividend 41. The double of 2, the partial root already found, is 4, to which a cipher is annexed, which gives 40 as the first trial divisor. This trial divisor is contained in the partial dividend but once, suggesting one as the second figure of the root. Adding one to 40, we obtain 41 as the correct divisor. This product (1×41), subtracted from the partial dividend 41, leaves no remainder and 21 is the required square root, since $21 \times 21 = 441$. In this manner may be found the square root of any number.

FINDING DIAMETER OF ROUND MAIN OF AREA EQUAL TO THAT OF TWO SQUARE BRANCHES

Solution 216

Fig. 672 is a perspective view of a two branched prong, one branch having indicated measurement

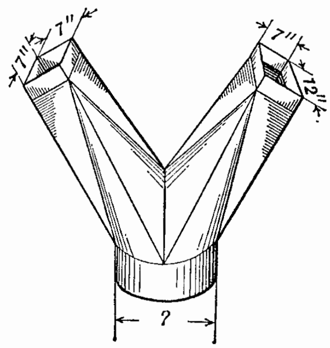

Fig. 672.—Finding the Diameter of a Round Main to Equal the Area of Square Branches

of 7 x 7 in. and the other 7 x 12 in. The former branch contains 49 sq. in., and the latter 84 sq. in. Thus, $49 + 84 = 133$ sq. in. The Areas table indicates the nearest calculation as 132.733, representing a 13 in. circle. Thus the round main requires to be of 13 in. diameter.

COMPUTING THE VARIOUS SIZE ROUND PIPES IN A VENTILATING SYSTEM

Solution 217

In Fig. 673 is shown a broken elevation of a ventilating system of round pipes and it is required to ascertain the increased sizes of the ducts A, B and C to take care of the respective 8, 10 and 12 in. branches. First compute the size of the main A, to take care of the 6 and 8 in. branches. Referring to the table, and following the column of Diameters, to 6, we find that its area is 28.2744. In like manner we find that the area of an 8 in. circle is 50.2656. Thus the combined area of the two pipes is 78.54. Now in the column of Areas 78.54 indicates a 10 in. circle. Thus the required diameter of pipe A is found to be of 10 in. The 10 in. branch is added to the right of A. What size must the pipe B have to contain the areas of the 6, 8 and

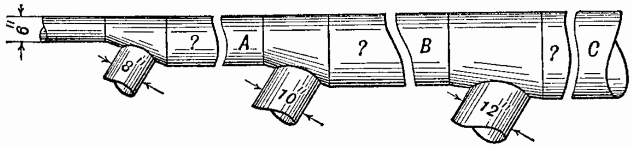

Fig. 673.— Computing Sizes of Round Pipe for a Ventilation System

10 in. branches combined? The area of A and that of the 10 in. branch is 78.54. Thus, $2 \times 78.54 = 157.08$. The nearest number in the column of Areas is found to be 159.485, which indicates a circle of 14¼ in. diameter as the required size of the pipe B. Add to 159.485, representing the area of B, the area of the 12 in. branch, which the table shows to be 113.098. We thus have as the total of the two areas 272.583. The nearest number thereto in the column of Areas is 276.117, indicating a circle of 18¾ in. diameter as the required size of the main pipe C. By these simple examples it will readily be seen that the more numerous the branches in a system of piping, the more convenient and necessary is the table of Circumferences and Areas for saving computation.

FINDING DIMENSIONS OF RECTANGULAR VERTICAL FLUE TO HAVE THE COMBINED AREAS OF SIX HORIZONTAL VENT. DUCTS

Solution 218

Fig. 674 shows a plan view of six rectangular vent. ducts, usually run along the ceiling from the

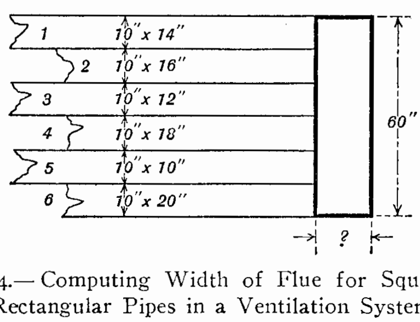

Fig. 674.— Computing Width of Flue for Square and Rectangular Pipes in a Ventilation System

various register inlets and providing ventilation for rooms. They terminate in a vertical sheet metal flue whose length is equal to that of the six ducts combined, or a total of 60 in. We must find the width of this flue whose area is equal to that of the six ventilating ducts combined. The first duct has 10×14 in. = 140 sq. in.; the second, 10×16 in. = 160 sq. in.; the third 10×12 in. = 120 sq. in.; the fourth 10×18 in. = 180 sq. in.; the fifth 10×10 in. = 100 sq. in., and the sixth 10×20 in. = 200 sq. in. Thus the total of the areas is as follows: $140 + 160 + 120 + 180 + 100 + 200 = 900$ sq. in. As all the ducts are set in the 10 in. way, as shown, the space taken up is $6 \times 10 = 60$ in. Now, simply divide the combined area of 900 by 60, obtaining the quotient 15 as the width of the flue. Thus a flue of 15 x 60 in. will have an area equal to the combined area of the six ducts in question, and it will be understood that the method is applicable to any shape or size of vent. ducts.

Calculating Pipe Sizes with the Steel Square. Examples Showing How the Ordinary Steel Square Can Be Used as a Lightning Calculator in Computing Pipe Work

No tool comprehended in the equipment of the shop merits more careful study than the steel square. The enterprising mechanic should not fail to appreciate that the steel square is not merely an instrument for taking measurements and squaring up work. By the aid of this universally useful tool many calculations, as those of pipe sizes, are ob-

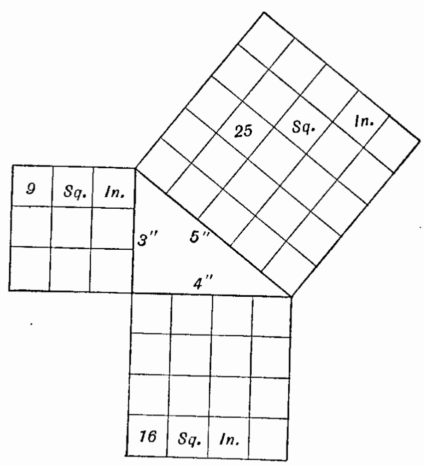

Fig. 675.— Proving the Geometrical Theorem

tained almost instantaneously. In fact, the mechanic who fails to understand the uses of the square is in the disadvantageous position of being compelled to resort to laborious and wasteful methods of figuring, with consequent liability to error. The following method of making calculations is based on the geometrical theorem that the square of the hypothenuse of a right angle triangle is equal to the sum of the squares of the base and altitude. Referring to Fig. 675 we have a right angle triangle with a four inch base and a three in. altitude. The square of the altitude is 3×3 or 9, as shown; the square of the base is 4×4 or 16, and $9 + 16 = 25$; $\sqrt{25} = 5$; $5 \times 5 = 25$. This principle thus indicated may be applied to the customary problems arising in pipe work.

FINDING SIZES OF PIPE IN TRUNK LINE SYSTEM BY AID OF THE STEEL SQUARE

Solution 219

Fig. 676 shows a plan view of a trunk line system of warm air heating pipes. Let us calculate the re-

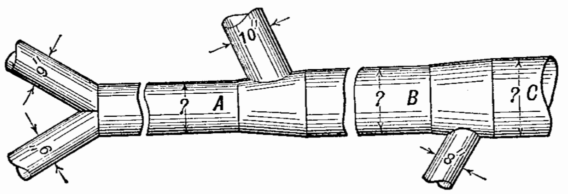

Fig. 676.— Plan of Trunk Line System of Hot Air Heating Pipes, the Sizes of Which Are Obtained from a Steel Square

quired sizes of pipe with the assistance of the steel square, illustrated in Fig. 677. In the present example, we have two 9 in., one 10 in., and one 8 in. branch, and seek to find the size of the pipe A for area equal to that of the two 9 in. branches; the size of the pipe B to have area equal to that of two 9 and one 10 in. branches, and the size of the pipe C to have the combined areas of two 9 in., one 10 in., and one 8 in. branches. These sizes are found in the space of a minute or two as follows: To compute the first two 9 in. branches, each shown in Fig. 676, lay the rule on the square from 9 to 9, in Fig. 677, and note that the distance from *a* to *b* is found to be 12¾ in., the size of pipe A. This pipe of 12¾ in. diameter is of equal area to that of the two 9 in. pipes. The next step is to find the diameter of the pipe B, in Fig. 676, to provide the combined area of the 12¾ in. for A and the 10 in. branch. Lay the rule on the square as in Fig. 677 from 10 to 12¾ as shown from *d* to *c*. The measure obtained is 16$\frac{3}{16}$ in., the diameter of the pipe B. Another 8 in. branch occurs below B, and thus it becomes necessary to find the diameter of the pipe C. Lay the rule on the square, as in Fig. 677, from 16$\frac{3}{16}$ to 8 as shown from *e* to *f*, obtaining measurement of 18 in. as the diameter of the main pipe C. The 18 in. pipe C is then of equal area to two 9 in., one 10 in., and one 8 in. branches, plus a slight fractional difference of no significance in practice. The accuracy of any such rule may be proved by performing the operation in reverse ways as indicated in the following examples.

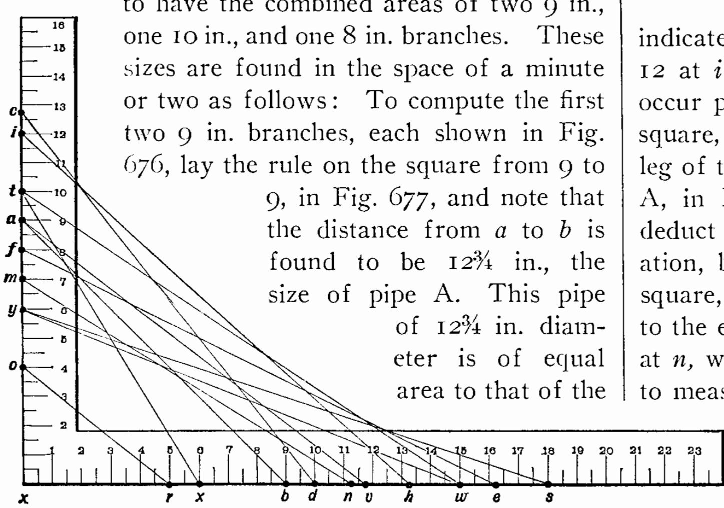

Fig. 677.— Obtaining the Pipe Sizes from the Steel Square

DETERMINING THE SIZE OF CONTINUING MAIN, WITH BRANCHES DEDUCTED

Solution 220

Fig. 678 is presented to show how the size of a reduced main is found, with a branch removed. Suppose the main to measure 18 in., as indicated, and that a 12 in. branch is taken off. Of what size must be the continuing pipe A? To provide the solution by means of the steel square, proceed as

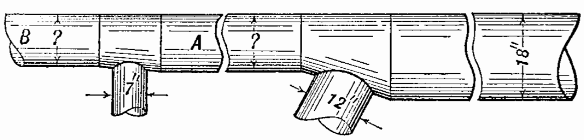

Fig. 678.— An Example for Proving the Rule Given in Preceding Problems

indicated in Fig. 677. Place one end of the rule on 12 at *i* with the figure 18 so adjusted that it will occur precisely at the edge of the other leg of the square, as shown at *h*. Then, reading on the lower leg of the square from X to *h*, we find that the pipe A, in Fig. 678, will have 13⅜ in. diameter. To deduct therefrom the 7 in. branch, repeat the operation, by placing one end of the rule on 7 of the square, in Fig. 677, at *m*, and bring 13⅜ on the rule to the edge of the other leg of the square as shown at *n*, when the distance from X to *n* will be found to measure 11⅜ in. Of course this method will be repeated for each branch deducted. The steel square is alike of useful application to finding the sizes of forks, prongs and branches.

FINDING DIAMETER OF ROUND MAIN IN A TWO BRANCHED FORK

Solution 221

Fig. 679 shows a two branched forked of 4 and 5 in. respectively. If it be desired to find the diameter of the main pipe, by the aid of the steel

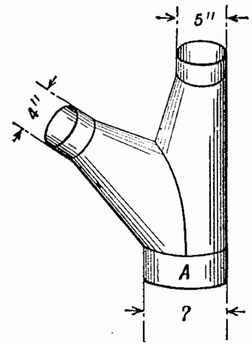

Fig. 679.—Finding Size of Round Main, in a Two Pronged Fork

square, set the rule from 4 to 5 on the square, shown in Fig. 677, from *o* to *r*, obtaining measure of 6½ in. The 6½ in., which is a very slight excess fraction, represents the diameter of the pipe A, in Fig. 679, and its area will equal the combined areas of the 4 and 5 in. branches.

FINDING THE DIAMETER OF ROUND MAIN IN THREE PRONGED FORK

Solution 222

The fork, shown in Fig. 680, possesses three branches measuring 6, 10 and 9 respectively. Of

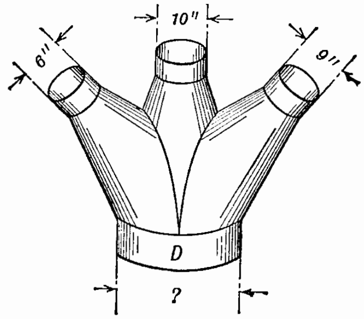

Fig. 680.—Finding Size of Round Main in a Three Pronged Fork

what size must be the main pipe to contain the combined areas of the three branches? By the ready aid of the steel square the result is quickly determined. For the first two branches, set the rule from 6 to 10, in Fig. 677, as shown from *x* to *t*, obtaining 11⅝ in. For the third or 9 in. branch, in Fig. 680, set the rule from 9 to 11⅝ on the square, in Fig. 677, as shown from *a* to *v*, obtaining 14¾ the size of the main duct D, in Fig. 680. Thus a 14¾ in. pipe has an area equal to the combined area of the 6, 10 and 9 in. branches.

FINDING SIZE OF SQUARE MAIN IN THREE BRANCHED FITTING WHOSE OUTLETS ARE SQUARE BUT VARY IN SIZE

Solution 223

The concluding example in the use of the steel square is represented in Fig. 681. Here we have

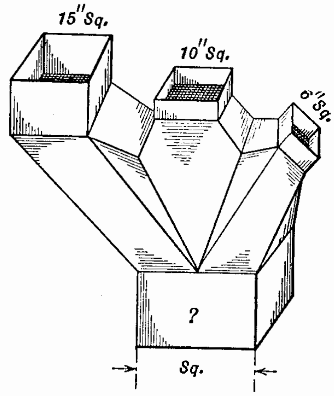

Fig. 681.—Finding Size of Square Main in a Three Branched Fitting

three outlets, a first 15 x 15 in., a second, 10 x 10 in., and a third, 6 x 6 in. There is no difference of procedure whether the outlets be square or round. Lay the rule on the steel square, in Fig. 677, from 15 to 10 as shown from *w* to *t*, obtaining measurement of 18 in. For the third or 6 in. branch, in Fig. 681, set the rule from 6 to 18 in., in Fig. 677, as shown from *y* to *s*, obtaining 19 in. The size of the main pipe in Fig. 681 will be made 19 in. square and its area will be equal to the combined areas of the 6, 10 and 15 in. square branches. A moderate degree of study on the part of the cutter who is not proficient in the use of the steel square will enable him to make it a quick and reliable source of help. It will be seen from the foregoing simply presented rules that the instrument is very nearly indispensable to furnacemen, mill and blow pipe makers, and erectors of heating and ventilation pipe, whether operating with round or square pipes, to which the rules are applicable alike.