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## HANDY TABLES,

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I.  
NUMERICAL CONSTANTS.

| $n$ | $n\pi$ | $\frac{n^2\pi}{4}$ | $n^3$ | $n^4$   | $\sqrt{n}$ | $\sqrt[3]{n}$ |
|-----|--------|--------------------|-------|---------|------------|---------------|
| 1.0 | 3.142  | 0.7854             | 1.000 | 1.000   | 1.0000     | 1.0000        |
| 1.1 | 3.456  | 0.9503             | 1.210 | 1.331   | 1.0488     | 1.0323        |
| 1.2 | 3.770  | 1.1310             | 1.440 | 1.728   | 1.0955     | 1.0627        |
| 1.3 | 4.084  | 1.3273             | 1.690 | 2.197   | 1.1402     | 1.0914        |
| 1.4 | 4.398  | 1.5394             | 1.960 | 2.744   | 1.1832     | 1.1187        |
| 1.5 | 4.712  | 1.7672             | 2.250 | 3.375   | 1.2247     | 1.1447        |
| 1.6 | 5.027  | 2.0106             | 2.560 | 4.096   | 1.2649     | 1.1696        |
| 1.7 | 5.341  | 2.2698             | 2.890 | 4.913   | 1.3038     | 1.1935        |
| 1.8 | 5.655  | 2.5447             | 3.240 | 5.832   | 1.3416     | 1.2164        |
| 1.9 | 5.969  | 2.8353             | 3.610 | 6.859   | 1.3784     | 1.2386        |
| 2.0 | 6.283  | 3.1416             | 4.000 | 8.000   | 1.4142     | 1.2599        |
| 2.1 | 6.597  | 3.4636             | 4.410 | 9.261   | 1.4491     | 1.2806        |
| 2.2 | 6.912  | 3.8013             | 4.840 | 10.648  | 1.4832     | 1.3006        |
| 2.3 | 7.226  | 4.1543             | 5.290 | 12.167  | 1.5166     | 1.3200        |
| 2.4 | 7.540  | 4.5239             | 5.760 | 13.824  | 1.5492     | 1.3389        |
| 2.5 | 7.854  | 4.9087             | 6.250 | 15.625  | 1.5811     | 1.3572        |
| 2.6 | 8.168  | 5.3093             | 6.760 | 17.576  | 1.6125     | 1.3751        |
| 2.7 | 8.482  | 5.7256             | 7.290 | 19.683  | 1.6432     | 1.3925        |
| 2.8 | 8.797  | 6.1575             | 7.840 | 21.952  | 1.6733     | 1.4095        |
| 2.9 | 9.111  | 6.6052             | 8.410 | 24.389  | 1.7029     | 1.4260        |
| 3.0 | 9.425  | 7.0686             | 9.000 | 27.000  | 1.7321     | 1.4422        |
| 3.1 | 9.739  | 7.5477             | 9.610 | 29.791  | 1.7607     | 1.4581        |
| 3.2 | 10.053 | 8.0425             | 10.24 | 32.768  | 1.7889     | 1.4736        |
| 3.3 | 10.367 | 8.5530             | 10.89 | 35.937  | 1.8166     | 1.4888        |
| 3.4 | 10.681 | 9.0792             | 11.56 | 39.304  | 1.8439     | 1.5037        |
| 3.5 | 10.996 | 9.6211             | 12.25 | 42.875  | 1.8708     | 1.5183        |
| 3.6 | 11.310 | 10.179             | 12.96 | 46.656  | 1.8974     | 1.5326        |
| 3.7 | 11.624 | 10.752             | 13.69 | 50.653  | 1.9235     | 1.5467        |
| 3.8 | 11.938 | 11.341             | 14.44 | 54.872  | 1.9494     | 1.5605        |
| 3.9 | 12.252 | 11.946             | 15.21 | 59.319  | 1.9748     | 1.5741        |
| 4.0 | 12.566 | 12.566             | 16.00 | 64.000  | 2.0000     | 1.5874        |
| 4.1 | 12.881 | 13.203             | 16.81 | 68.921  | 2.0249     | 1.6005        |
| 4.2 | 13.195 | 13.854             | 17.64 | 74.088  | 2.0494     | 1.6134        |
| 4.3 | 13.509 | 14.522             | 18.49 | 79.507  | 2.0736     | 1.6261        |
| 4.4 | 13.823 | 15.205             | 19.36 | 85.184  | 2.0976     | 1.6386        |
| 4.5 | 14.137 | 15.904             | 20.25 | 91.125  | 2.1213     | 1.6510        |
| 4.6 | 14.451 | 16.619             | 21.16 | 97.336  | 2.1448     | 1.6631        |
| 4.7 | 14.765 | 17.349             | 22.09 | 103.823 | 2.1680     | 1.6751        |

## CONSTANTS—Continued.

| $n$ | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$ | $n^3$   | $\sqrt{n}$ | $\frac{1}{\sqrt{n}}$ |
|-----|--------|---------------------|-------|---------|------------|----------------------|
| 4.8 | 15.080 | 18.096              | 23.04 | 110.592 | 2.1909     | 1.6869               |
| 4.9 | 15.394 | 18.857              | 24.01 | 117.649 | 2.2136     | 1.6985               |
| 5.0 | 15.708 | 19.635              | 25.00 | 125.000 | 2.2361     | 1.7100               |
| 5.1 | 16.022 | 20.428              | 26.01 | 132.651 | 2.2583     | 1.7213               |
| 5.2 | 16.336 | 21.237              | 27.04 | 140.608 | 2.2804     | 1.7325               |
| 5.3 | 16.650 | 22.062              | 28.09 | 148.877 | 2.3022     | 1.7435               |
| 5.4 | 16.965 | 22.902              | 29.16 | 157.464 | 2.3238     | 1.7544               |
| 5.5 | 17.279 | 23.758              | 30.25 | 166.375 | 2.3452     | 1.7652               |
| 5.6 | 17.593 | 24.630              | 31.36 | 175.616 | 2.3664     | 1.7758               |
| 5.7 | 17.907 | 25.518              | 32.49 | 185.193 | 2.3875     | 1.7863               |
| 5.8 | 18.221 | 26.421              | 33.64 | 195.112 | 2.4083     | 1.7967               |
| 5.9 | 18.535 | 27.340              | 34.81 | 205.379 | 2.4290     | 1.8070               |
| 6.0 | 18.850 | 28.274              | 36.00 | 216.000 | 2.4495     | 1.8171               |
| 6.1 | 19.164 | 29.225              | 37.21 | 226.981 | 2.4698     | 1.8272               |
| 6.2 | 19.478 | 30.191              | 38.44 | 238.328 | 2.4900     | 1.8371               |
| 6.3 | 19.792 | 31.173              | 39.69 | 250.047 | 2.5100     | 1.8469               |
| 6.4 | 20.106 | 32.170              | 40.96 | 262.144 | 2.5298     | 1.8566               |
| 6.5 | 20.420 | 33.183              | 42.25 | 274.625 | 2.5495     | 1.8663               |
| 6.6 | 20.735 | 34.212              | 43.56 | 287.496 | 2.5691     | 1.8758               |
| 6.7 | 21.049 | 35.257              | 44.89 | 300.763 | 2.5884     | 1.8852               |
| 6.8 | 21.363 | 36.317              | 46.24 | 314.432 | 2.6077     | 1.8945               |
| 6.9 | 21.677 | 37.393              | 47.61 | 328.509 | 2.6268     | 1.9038               |
| 7.0 | 21.991 | 38.485              | 49.00 | 343.000 | 2.6458     | 1.9129               |
| 7.1 | 22.305 | 39.592              | 50.41 | 357.911 | 2.6646     | 1.9220               |
| 7.2 | 22.619 | 40.715              | 51.84 | 373.248 | 2.6833     | 1.9310               |
| 7.3 | 22.934 | 41.854              | 53.29 | 389.017 | 2.7019     | 1.9399               |
| 7.4 | 23.248 | 43.008              | 54.76 | 405.224 | 2.7203     | 1.9487               |
| 7.5 | 23.562 | 44.179              | 56.25 | 421.875 | 2.7386     | 1.9574               |
| 7.6 | 23.876 | 45.365              | 57.76 | 438.976 | 2.7568     | 1.9661               |
| 7.7 | 24.190 | 46.566              | 59.29 | 456.533 | 2.7749     | 1.9747               |
| 7.8 | 24.504 | 47.784              | 60.84 | 474.552 | 2.7929     | 1.9832               |
| 7.9 | 24.819 | 49.017              | 62.41 | 493.039 | 2.8107     | 1.9916               |
| 8.0 | 25.133 | 50.266              | 64.00 | 512.000 | 2.8284     | 2.0000               |
| 8.1 | 25.447 | 51.530              | 65.61 | 531.441 | 2.8461     | 2.0083               |
| 8.2 | 25.761 | 52.810              | 67.24 | 551.468 | 2.8636     | 2.0165               |
| 8.3 | 26.075 | 54.106              | 68.89 | 571.787 | 2.8810     | 2.0247               |
| 8.4 | 26.389 | 55.418              | 70.56 | 592.704 | 2.8983     | 2.0328               |
| 8.5 | 26.704 | 56.745              | 72.25 | 614.125 | 2.9155     | 2.0408               |
| 8.6 | 27.018 | 58.088              | 73.96 | 636.056 | 2.9326     | 2.0488               |
| 8.7 | 27.332 | 59.447              | 75.69 | 658.503 | 2.9496     | 2.0567               |
| 8.8 | 27.646 | 60.821              | 77.44 | 681.473 | 2.9665     | 2.0646               |
| 8.9 | 27.960 | 62.211              | 79.21 | 704.969 | 2.9833     | 2.0724               |

## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$  | $n^3$    | $\sqrt{n}$ | $\frac{1}{\sqrt{n}}$ |
|------|--------|---------------------|--------|----------|------------|----------------------|
| 9.0  | 28.274 | 63.617              | 81.00  | 729.000  | 3.0000     | 2.0801               |
| 9.1  | 28.588 | 65.039              | 82.81  | 753.571  | 3.0166     | 2.0878               |
| 9.2  | 28.903 | 66.476              | 84.64  | 778.688  | 3.0332     | 2.0954               |
| 9.3  | 29.217 | 67.929              | 86.49  | 804.357  | 3.0496     | 2.1029               |
| 9.4  | 29.531 | 69.398              | 88.36  | 830.584  | 3.0659     | 2.1105               |
| 9.5  | 29.845 | 70.882              | 90.25  | 857.375  | 3.0822     | 2.1179               |
| 9.6  | 30.159 | 72.382              | 92.16  | 884.736  | 3.0984     | 2.1253               |
| 9.7  | 30.473 | 73.898              | 94.09  | 912.673  | 3.1145     | 2.1327               |
| 9.8  | 30.788 | 75.430              | 96.04  | 941.192  | 3.1305     | 2.1400               |
| 9.9  | 31.102 | 76.977              | 98.01  | 970.299  | 3.1464     | 2.1472               |
| 10.0 | 31.416 | 78.540              | 100.00 | 1000.000 | 3.1623     | 2.1544               |
| 10.1 | 31.730 | 80.119              | 102.01 | 1030.301 | 3.1780     | 2.1616               |
| 10.2 | 32.044 | 81.713              | 104.04 | 1061.208 | 3.1937     | 2.1687               |
| 10.3 | 32.358 | 83.323              | 106.09 | 1092.727 | 3.2094     | 2.1757               |
| 10.4 | 32.673 | 84.949              | 108.16 | 1124.863 | 3.2249     | 2.1828               |
| 10.5 | 32.987 | 86.590              | 110.25 | 1157.625 | 3.2404     | 2.1897               |
| 10.6 | 33.301 | 88.247              | 112.36 | 1191.016 | 3.2558     | 2.1967               |
| 10.7 | 33.615 | 89.920              | 114.49 | 1225.043 | 3.2711     | 2.2036               |
| 10.8 | 33.929 | 91.609              | 116.64 | 1259.712 | 3.2863     | 2.2104               |
| 10.9 | 34.243 | 93.313              | 118.81 | 1295.029 | 3.3015     | 2.2172               |
| 11.0 | 34.558 | 95.033              | 121.00 | 1331.000 | 3.3166     | 2.2239               |
| 11.1 | 34.872 | 96.769              | 123.21 | 1367.631 | 3.3317     | 2.2307               |
| 11.2 | 35.186 | 98.520              | 125.44 | 1404.928 | 3.3466     | 2.2374               |
| 11.3 | 35.500 | 100.29              | 127.69 | 1442.897 | 3.3615     | 2.2441               |
| 11.4 | 35.814 | 102.07              | 129.96 | 1481.544 | 3.3764     | 2.2506               |
| 11.5 | 36.128 | 103.87              | 132.25 | 1520.875 | 3.3912     | 2.2572               |
| 11.6 | 36.442 | 105.68              | 134.56 | 1560.896 | 3.4059     | 2.2637               |
| 11.7 | 36.757 | 107.51              | 136.89 | 1601.613 | 3.4205     | 2.2702               |
| 11.8 | 37.071 | 109.36              | 139.24 | 1643.032 | 3.4351     | 2.2766               |
| 11.9 | 37.385 | 111.22              | 141.61 | 1685.159 | 3.4496     | 2.2831               |
| 12.0 | 37.699 | 113.10              | 144.00 | 1728.000 | 3.4641     | 2.2894               |
| 12.1 | 38.013 | 114.99              | 146.41 | 1771.561 | 3.4785     | 2.2957               |
| 12.2 | 38.327 | 116.90              | 148.84 | 1815.848 | 3.4928     | 2.3021               |
| 12.3 | 38.642 | 118.82              | 151.29 | 1860.867 | 3.5071     | 2.3084               |
| 12.4 | 38.956 | 120.76              | 153.76 | 1906.624 | 3.5214     | 2.3146               |
| 12.5 | 39.270 | 122.72              | 156.25 | 1953.125 | 3.5355     | 2.3208               |
| 12.6 | 39.584 | 124.69              | 158.76 | 2000.376 | 3.5496     | 2.3270               |
| 12.7 | 39.898 | 126.68              | 161.29 | 2048.383 | 3.5637     | 2.3331               |
| 12.8 | 40.212 | 128.68              | 163.84 | 2097.152 | 3.5777     | 2.3392               |
| 12.9 | 40.527 | 130.70              | 166.41 | 2146.689 | 3.5917     | 2.3453               |
| 13.0 | 40.841 | 132.73              | 169.00 | 2197.000 | 3.6056     | 2.3513               |
| 13.1 | 41.155 | 134.78              | 171.61 | 2248.091 | 3.6194     | 2.3573               |
| 13.2 | 41.469 | 136.85              | 174.24 | 2299.968 | 3.6332     | 2.3633               |



HANDY TABLES.

CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$  | $n^3$    | $\sqrt{n}$ | $\frac{1}{\sqrt{n}}$ |
|------|--------|---------------------|--------|----------|------------|----------------------|
| 13.3 | 41.783 | 138.93              | 176.89 | 2352.637 | 3.6469     | 2.3693               |
| 13.4 | 42.097 | 141.03              | 179.56 | 2406.104 | 3.6606     | 2.3752               |
| 13.5 | 42.412 | 143.14              | 182.25 | 2460.375 | 3.6742     | 2.3811               |
| 13.6 | 42.726 | 145.27              | 184.96 | 2515.456 | 3.6878     | 2.3870               |
| 13.7 | 43.040 | 147.41              | 187.69 | 2571.353 | 3.7013     | 2.3928               |
| 13.8 | 43.354 | 149.57              | 190.44 | 2628.072 | 3.7148     | 2.3986               |
| 13.9 | 43.668 | 151.75              | 193.21 | 2685.619 | 3.7283     | 2.4044               |
| 14.0 | 43.982 | 153.94              | 196.00 | 2744.000 | 3.7417     | 2.4101               |
| 14.1 | 44.296 | 156.15              | 198.81 | 2803.221 | 3.7550     | 2.4159               |
| 14.2 | 44.611 | 158.37              | 201.64 | 2863.288 | 3.7683     | 2.4216               |
| 14.3 | 44.925 | 160.61              | 204.49 | 2924.207 | 3.7815     | 2.4272               |
| 14.4 | 45.239 | 162.86              | 207.36 | 2985.984 | 3.7947     | 2.4329               |
| 14.5 | 45.553 | 165.13              | 210.25 | 3048.625 | 3.8079     | 2.4385               |
| 14.6 | 45.867 | 167.42              | 213.16 | 3112.136 | 3.8210     | 2.4441               |
| 14.7 | 46.181 | 169.72              | 216.09 | 3176.523 | 3.8341     | 2.4497               |
| 14.8 | 46.496 | 172.03              | 219.04 | 3241.792 | 3.8471     | 2.4552               |
| 14.9 | 46.810 | 174.37              | 222.01 | 3307.949 | 3.8600     | 2.4607               |
| 15.0 | 47.124 | 176.72              | 225.00 | 3375.000 | 3.8730     | 2.4662               |
| 15.1 | 47.438 | 179.08              | 228.01 | 3442.951 | 3.8859     | 2.4717               |
| 15.2 | 47.752 | 181.46              | 231.04 | 3511.808 | 3.8987     | 2.4772               |
| 15.3 | 48.066 | 183.85              | 234.09 | 3581.577 | 3.9115     | 2.4825               |
| 15.4 | 48.381 | 186.27              | 237.16 | 3652.264 | 3.9243     | 2.4879               |
| 15.5 | 48.695 | 188.69              | 240.25 | 3723.875 | 3.9370     | 2.4933               |
| 15.6 | 49.009 | 191.13              | 243.36 | 3796.416 | 3.9497     | 2.4986               |
| 15.7 | 49.323 | 193.59              | 246.49 | 3869.893 | 3.9623     | 2.5039               |
| 15.8 | 49.637 | 196.07              | 249.64 | 3944.312 | 3.9749     | 2.5092               |
| 15.9 | 49.951 | 198.56              | 252.81 | 4019.679 | 3.9875     | 2.5146               |
| 16.0 | 50.265 | 201.06              | 256.00 | 4096.000 | 4.0000     | 2.5198               |
| 16.1 | 50.580 | 203.58              | 259.21 | 4173.281 | 4.0125     | 2.5251               |
| 16.2 | 50.894 | 206.12              | 262.44 | 4251.528 | 4.0249     | 2.5303               |
| 16.3 | 51.208 | 208.67              | 265.69 | 4330.747 | 4.0373     | 2.5355               |
| 16.4 | 51.522 | 211.24              | 268.96 | 4410.944 | 4.0497     | 2.5406               |
| 16.5 | 51.836 | 213.83              | 272.25 | 4492.125 | 4.0620     | 2.5458               |
| 16.6 | 52.150 | 216.42              | 275.56 | 4574.296 | 4.0743     | 2.5509               |
| 16.7 | 52.465 | 219.04              | 278.89 | 4657.463 | 4.0866     | 2.5561               |
| 16.8 | 52.779 | 221.67              | 282.24 | 4741.632 | 4.0988     | 2.5612               |
| 16.9 | 53.093 | 224.32              | 285.61 | 4826.809 | 4.1110     | 2.5663               |
| 17.0 | 53.407 | 226.98              | 289.00 | 4913.000 | 4.1231     | 2.5713               |
| 17.1 | 53.721 | 229.66              | 292.41 | 5000.211 | 4.1352     | 2.5763               |
| 17.2 | 54.035 | 232.35              | 295.84 | 5088.448 | 4.1473     | 2.5813               |
| 17.3 | 54.350 | 235.06              | 299.29 | 5177.717 | 4.1593     | 2.5863               |
| 17.4 | 54.664 | 237.79              | 302.76 | 5268.024 | 4.1713     | 2.5913               |



## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$  | $n^3$     | $\sqrt{n}$ | $\frac{1}{\sqrt{n}}$ |
|------|--------|---------------------|--------|-----------|------------|----------------------|
| 17.5 | 54.978 | 240.53              | 306.25 | 5359.375  | 4.1833     | 2.5963               |
| 17.6 | 55.292 | 243.29              | 309.76 | 5451.776  | 4.1952     | 2.6012               |
| 17.7 | 55.606 | 246.06              | 313.29 | 5545.233  | 4.2071     | 2.6061               |
| 17.8 | 55.920 | 248.85              | 316.84 | 5639.752  | 4.2190     | 2.6109               |
| 17.9 | 56.235 | 251.65              | 320.41 | 5735.339  | 4.2308     | 2.6158               |
| 18.0 | 56.549 | 254.47              | 324.00 | 5832.000  | 4.2426     | 2.6207               |
| 18.1 | 56.863 | 257.30              | 327.61 | 5929.741  | 4.2544     | 2.6256               |
| 18.2 | 57.177 | 260.16              | 331.24 | 6028.568  | 4.2661     | 2.6304               |
| 18.3 | 57.491 | 263.02              | 334.89 | 6128.487  | 4.2778     | 2.6352               |
| 18.4 | 57.805 | 265.90              | 338.56 | 6229.504  | 4.2895     | 2.6401               |
| 18.5 | 58.119 | 268.80              | 342.25 | 6331.625  | 4.3012     | 2.6448               |
| 18.6 | 58.434 | 271.72              | 345.96 | 6434.856  | 4.3128     | 2.6495               |
| 18.7 | 58.748 | 274.65              | 349.69 | 6539.203  | 4.3243     | 2.6543               |
| 18.8 | 59.062 | 277.59              | 353.44 | 6644.672  | 4.3359     | 2.6590               |
| 18.9 | 59.376 | 280.55              | 357.21 | 6751.269  | 4.3474     | 2.6637               |
| 19.0 | 59.690 | 283.53              | 361.00 | 6859.000  | 4.3589     | 2.6684               |
| 19.1 | 60.004 | 286.52              | 364.81 | 6967.871  | 4.3703     | 2.6731               |
| 19.2 | 60.319 | 289.53              | 368.64 | 7077.888  | 4.3818     | 2.6777               |
| 19.3 | 60.633 | 292.55              | 372.49 | 7189.057  | 4.3932     | 2.6824               |
| 19.4 | 60.947 | 295.59              | 376.36 | 7301.384  | 4.4045     | 2.6869               |
| 19.5 | 61.261 | 298.65              | 380.25 | 7414.875  | 4.4159     | 2.6916               |
| 19.6 | 61.575 | 301.72              | 384.16 | 7529.536  | 4.4272     | 2.6962               |
| 19.7 | 61.889 | 304.81              | 388.09 | 7645.373  | 4.4385     | 2.7008               |
| 19.8 | 62.204 | 307.91              | 392.04 | 7762.392  | 4.4497     | 2.7053               |
| 19.9 | 62.518 | 311.03              | 396.01 | 7880.599  | 4.4609     | 2.7098               |
| 20.0 | 62.832 | 314.16              | 400.00 | 8000.000  | 4.4721     | 2.7144               |
| 20.1 | 63.146 | 317.31              | 404.01 | 8120.601  | 4.4833     | 2.7189               |
| 20.2 | 63.460 | 320.47              | 408.04 | 8242.408  | 4.4944     | 2.7234               |
| 20.3 | 63.774 | 323.66              | 412.09 | 8365.427  | 4.5055     | 2.7279               |
| 20.4 | 64.088 | 326.85              | 416.16 | 8489.664  | 4.5166     | 2.7324               |
| 20.5 | 64.403 | 330.06              | 420.25 | 8615.125  | 4.5277     | 2.7368               |
| 20.6 | 64.717 | 333.29              | 424.36 | 8741.816  | 4.5387     | 2.7413               |
| 20.7 | 65.031 | 336.54              | 428.49 | 8869.743  | 4.5497     | 2.7457               |
| 20.8 | 65.345 | 339.80              | 432.64 | 8999.912  | 4.5607     | 2.7502               |
| 20.9 | 65.659 | 343.07              | 436.81 | 9129.329  | 4.5716     | 2.7545               |
| 21.0 | 65.973 | 346.36              | 441.00 | 9261.000  | 4.5826     | 2.7589               |
| 21.1 | 66.288 | 349.67              | 445.21 | 9393.931  | 4.5935     | 2.7633               |
| 21.2 | 66.602 | 352.99              | 449.44 | 9528.128  | 4.6043     | 2.7676               |
| 21.3 | 66.916 | 356.33              | 453.69 | 9663.597  | 4.6152     | 2.7720               |
| 21.4 | 67.230 | 359.68              | 457.96 | 9800.344  | 4.6260     | 2.7763               |
| 21.5 | 67.544 | 363.05              | 462.25 | 9938.375  | 4.6368     | 2.7806               |
| 21.6 | 67.858 | 366.44              | 466.56 | 10077.696 | 4.6476     | 2.7849               |
| 21.7 | 68.173 | 369.84              | 470.89 | 10218.313 | 4.6583     | 2.7893               |

## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$  | $n^3$     | $\sqrt{n}$ | $\frac{2}{\sqrt{n}}$ |
|------|--------|---------------------|--------|-----------|------------|----------------------|
| 21.8 | 68.487 | 373.25              | 475.24 | 10360.232 | 4.6690     | 2.7935               |
| 21.9 | 68.801 | 376.69              | 479.61 | 10503.459 | 4.6797     | 2.7978               |
| 22.0 | 69.115 | 380.13              | 484.00 | 10648.000 | 4.6904     | 2.8021               |
| 22.1 | 69.429 | 383.60              | 488.41 | 10793.861 | 4.7011     | 2.8063               |
| 22.2 | 69.743 | 387.08              | 492.84 | 10941.048 | 4.7117     | 2.8105               |
| 22.3 | 70.058 | 390.57              | 497.29 | 11089.567 | 4.7223     | 2.8147               |
| 22.4 | 70.372 | 394.08              | 501.76 | 11239.424 | 4.7329     | 2.8189               |
| 22.5 | 70.686 | 397.61              | 506.25 | 11390.625 | 4.7434     | 2.8231               |
| 22.6 | 71.000 | 401.15              | 510.76 | 11543.176 | 4.7539     | 2.8273               |
| 22.7 | 71.314 | 404.71              | 515.29 | 11697.083 | 4.7644     | 2.8314               |
| 22.8 | 71.628 | 408.28              | 519.84 | 11852.352 | 4.7749     | 2.8356               |
| 22.9 | 71.942 | 411.87              | 524.41 | 12008.989 | 4.7854     | 2.8397               |
| 23.0 | 72.257 | 415.48              | 529.00 | 12167.000 | 4.7958     | 2.8438               |
| 23.1 | 72.571 | 419.10              | 533.61 | 12326.391 | 4.8062     | 2.8479               |
| 23.2 | 72.885 | 422.73              | 538.24 | 12487.168 | 4.8166     | 2.8521               |
| 23.3 | 73.199 | 426.39              | 542.89 | 12649.337 | 4.8270     | 2.8562               |
| 23.4 | 73.513 | 430.05              | 547.56 | 12812.904 | 4.8373     | 2.8603               |
| 23.5 | 73.827 | 433.74              | 552.25 | 12977.875 | 4.8477     | 2.8643               |
| 23.6 | 74.142 | 437.44              | 556.96 | 13144.256 | 4.8580     | 2.8684               |
| 23.7 | 74.456 | 441.15              | 561.69 | 13312.053 | 4.8683     | 2.8724               |
| 23.8 | 74.770 | 444.88              | 566.44 | 13481.272 | 4.8785     | 2.8765               |
| 23.9 | 75.084 | 448.63              | 571.21 | 13651.919 | 4.8888     | 2.8805               |
| 24.0 | 75.398 | 452.39              | 576.00 | 13824.000 | 4.8990     | 2.8845               |
| 24.1 | 75.712 | 456.17              | 580.81 | 13997.521 | 4.9092     | 2.8885               |
| 24.2 | 76.027 | 459.96              | 585.64 | 14172.488 | 4.9193     | 2.8925               |
| 24.3 | 76.341 | 463.77              | 590.49 | 14348.907 | 4.9295     | 2.8965               |
| 24.4 | 76.655 | 467.60              | 595.36 | 14526.784 | 4.9396     | 2.9004               |
| 24.5 | 76.969 | 471.44              | 600.25 | 14706.125 | 4.9497     | 2.9044               |
| 24.6 | 77.283 | 475.29              | 605.16 | 14886.936 | 4.9598     | 2.9083               |
| 24.7 | 77.597 | 479.16              | 610.09 | 15069.223 | 4.9699     | 2.9123               |
| 24.8 | 77.911 | 483.05              | 615.04 | 15252.992 | 4.9799     | 2.9162               |
| 24.9 | 78.226 | 486.96              | 620.01 | 15438.249 | 4.9899     | 2.9201               |
| 25.0 | 78.540 | 490.87              | 625.00 | 15625.000 | 5.0000     | 2.9241               |
| 25.1 | 78.854 | 494.81              | 630.01 | 15813.251 | 5.0099     | 2.9279               |
| 25.2 | 79.168 | 498.76              | 635.04 | 16003.008 | 5.0199     | 2.9318               |
| 25.3 | 79.482 | 502.73              | 640.09 | 16194.277 | 5.0299     | 2.9356               |
| 25.4 | 79.796 | 506.71              | 645.16 | 16387.064 | 5.0398     | 2.9395               |
| 25.5 | 80.111 | 510.71              | 650.25 | 16581.375 | 5.0497     | 2.9434               |
| 25.6 | 80.425 | 514.72              | 655.36 | 16777.216 | 5.0596     | 2.9472               |
| 25.7 | 80.739 | 518.75              | 660.49 | 16974.593 | 5.0695     | 2.9510               |
| 25.8 | 81.053 | 522.79              | 665.64 | 17173.512 | 5.0793     | 2.9549               |
| 25.9 | 81.367 | 526.85              | 670.81 | 17373.979 | 5.0892     | 2.9586               |

## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$  | $n^3$     | $\sqrt{n}$ | $\frac{2}{\sqrt{n}}$ |
|------|--------|---------------------|--------|-----------|------------|----------------------|
| 26.0 | 81.681 | 530.93              | 676.00 | 17576.000 | 5.0990     | 2.9624               |
| 26.1 | 81.996 | 535.02              | 681.21 | 17779.581 | 5.1088     | 2.9662               |
| 26.2 | 82.310 | 539.13              | 686.44 | 17984.728 | 5.1185     | 2.9701               |
| 26.3 | 82.624 | 543.25              | 691.69 | 18191.447 | 5.1283     | 2.9738               |
| 26.4 | 82.938 | 547.39              | 696.96 | 18399.744 | 5.1380     | 2.9776               |
| 26.5 | 83.252 | 551.55              | 702.25 | 18609.625 | 5.1478     | 2.9814               |
| 26.6 | 83.566 | 555.72              | 707.56 | 18821.096 | 5.1575     | 2.9851               |
| 26.7 | 83.881 | 559.90              | 712.89 | 19034.163 | 5.1672     | 2.9888               |
| 26.8 | 84.195 | 564.10              | 718.24 | 19248.832 | 5.1768     | 2.9926               |
| 26.9 | 84.509 | 568.32              | 723.61 | 19465.109 | 5.1865     | 2.9963               |
| 27.0 | 84.823 | 572.56              | 729.00 | 19683.000 | 5.1962     | 3.0000               |
| 27.1 | 85.137 | 576.80              | 734.41 | 19902.511 | 5.2057     | 3.0037               |
| 27.2 | 85.451 | 581.07              | 739.84 | 20123.648 | 5.2153     | 3.0074               |
| 27.3 | 85.765 | 585.35              | 745.29 | 20346.417 | 5.2249     | 3.0111               |
| 27.4 | 86.080 | 589.65              | 750.76 | 20570.824 | 5.2345     | 3.0147               |
| 27.5 | 86.394 | 593.96              | 756.25 | 20796.875 | 5.2440     | 3.0184               |
| 27.6 | 86.708 | 598.29              | 761.76 | 21024.576 | 5.2535     | 3.0221               |
| 27.7 | 87.022 | 602.63              | 767.29 | 21253.933 | 5.2630     | 3.0257               |
| 27.8 | 87.336 | 606.99              | 772.84 | 21484.952 | 5.2725     | 3.0293               |
| 27.9 | 87.650 | 611.36              | 778.41 | 21717.639 | 5.2820     | 3.0330               |
| 28.0 | 87.965 | 615.75              | 784.00 | 21952.000 | 5.2915     | 3.0366               |
| 28.1 | 88.279 | 620.16              | 789.61 | 22188.041 | 5.3009     | 3.0402               |
| 28.2 | 88.593 | 624.58              | 795.24 | 22425.768 | 5.3103     | 3.0438               |
| 28.3 | 88.907 | 629.02              | 800.89 | 22665.187 | 5.3197     | 3.0474               |
| 28.4 | 89.221 | 633.47              | 806.56 | 22906.304 | 5.3291     | 3.0510               |
| 28.5 | 89.535 | 637.94              | 812.25 | 23149.125 | 5.3385     | 3.0546               |
| 28.6 | 89.850 | 642.42              | 817.96 | 23393.656 | 5.3478     | 3.0581               |
| 28.7 | 90.164 | 646.93              | 823.69 | 23639.903 | 5.3572     | 3.0617               |
| 28.8 | 90.478 | 651.44              | 829.44 | 23887.872 | 5.3665     | 3.0652               |
| 28.9 | 90.792 | 655.97              | 835.21 | 24137.569 | 5.3758     | 3.0688               |
| 29.0 | 91.106 | 660.52              | 841.00 | 24389.000 | 5.3852     | 3.0723               |
| 29.1 | 91.420 | 665.08              | 846.81 | 24642.171 | 5.3944     | 3.0758               |
| 29.2 | 91.735 | 669.66              | 852.64 | 24897.088 | 5.4037     | 3.0794               |
| 29.3 | 92.049 | 674.26              | 858.49 | 25153.757 | 5.4129     | 3.0829               |
| 29.4 | 92.363 | 678.87              | 864.36 | 25412.184 | 5.4221     | 3.0864               |
| 29.5 | 92.677 | 683.49              | 870.25 | 25672.375 | 5.4313     | 3.0899               |
| 29.6 | 92.991 | 688.13              | 876.16 | 25934.336 | 5.4405     | 3.0934               |
| 29.7 | 93.305 | 692.79              | 882.09 | 26198.073 | 5.4497     | 3.0968               |
| 29.8 | 93.619 | 697.47              | 888.04 | 26463.592 | 5.4589     | 3.1003               |
| 29.9 | 93.934 | 702.15              | 894.01 | 26730.899 | 5.4680     | 3.1038               |
| 30.0 | 94.248 | 706.86              | 900.00 | 27000.000 | 5.4772     | 3.1072               |
| 30.1 | 94.562 | 711.58              | 906.01 | 27270.901 | 5.4863     | 3.1107               |
| 30.2 | 94.876 | 716.32              | 912.04 | 27543.608 | 5.4954     | 3.1141               |

## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$   | $n^3$     | $\sqrt{n}$ | $\frac{3}{\sqrt{n}}$ |
|------|--------|---------------------|---------|-----------|------------|----------------------|
| 30.3 | 95.190 | 721.07              | 918.09  | 27818.127 | 5.5045     | 3.1176               |
| 30.4 | 95.505 | 725.83              | 924.16  | 28094.464 | 5.5136     | 3.1210               |
| 30.5 | 95.819 | 730.62              | 930.25  | 28372.625 | 5.5226     | 3.1244               |
| 30.6 | 96.133 | 735.42              | 936.36  | 28652.616 | 5.5317     | 3.1278               |
| 30.7 | 96.447 | 740.23              | 942.49  | 28934.443 | 5.5407     | 3.1312               |
| 30.8 | 96.761 | 745.06              | 948.64  | 29218.112 | 5.5497     | 3.1346               |
| 30.9 | 97.075 | 749.91              | 954.81  | 29503.629 | 5.5587     | 3.1380               |
| 31.0 | 97.389 | 754.77              | 961.00  | 29791.000 | 5.5678     | 3.1414               |
| 31.1 | 97.704 | 759.65              | 967.21  | 30080.231 | 5.5767     | 3.1448               |
| 31.2 | 98.018 | 764.54              | 973.44  | 30371.328 | 5.5857     | 3.1481               |
| 31.3 | 98.332 | 769.45              | 979.69  | 30664.297 | 5.5946     | 3.1515               |
| 31.4 | 98.646 | 774.37              | 985.96  | 30959.144 | 5.6035     | 3.1548               |
| 31.5 | 98.960 | 779.31              | 992.25  | 31255.875 | 5.6124     | 3.1582               |
| 31.6 | 99.274 | 784.27              | 998.56  | 31554.496 | 5.6213     | 3.1615               |
| 31.7 | 99.588 | 789.24              | 1004.89 | 31855.013 | 5.6302     | 3.1648               |
| 31.8 | 99.903 | 794.23              | 1011.24 | 32157.432 | 5.6391     | 3.1681               |
| 31.9 | 100.22 | 799.23              | 1017.61 | 32461.759 | 5.6480     | 3.1715               |
| 32.0 | 100.53 | 804.25              | 1024.00 | 32768.000 | 5.6569     | 3.1748               |
| 32.1 | 100.85 | 809.28              | 1030.41 | 33076.161 | 5.6656     | 3.1781               |
| 32.2 | 101.16 | 814.33              | 1036.84 | 33386.248 | 5.6745     | 3.1814               |
| 32.3 | 101.47 | 819.40              | 1043.29 | 33698.267 | 5.6833     | 3.1847               |
| 32.4 | 101.79 | 824.48              | 1049.76 | 34012.224 | 5.6921     | 3.1880               |
| 32.5 | 102.10 | 829.58              | 1056.25 | 34328.125 | 5.7008     | 3.1913               |
| 32.6 | 102.42 | 834.69              | 1062.76 | 34645.976 | 5.7096     | 3.1945               |
| 32.7 | 102.73 | 839.82              | 1069.29 | 34965.783 | 5.7183     | 3.1978               |
| 32.8 | 103.04 | 844.96              | 1075.84 | 35287.552 | 5.7271     | 3.2010               |
| 32.9 | 103.36 | 850.12              | 1082.41 | 35611.289 | 5.7358     | 3.2043               |
| 33.0 | 103.67 | 855.30              | 1089.00 | 35937.000 | 5.7446     | 3.2075               |
| 33.1 | 103.99 | 860.49              | 1095.61 | 36264.691 | 5.7532     | 3.2108               |
| 33.2 | 104.30 | 865.70              | 1102.24 | 36594.368 | 5.7619     | 3.2140               |
| 33.3 | 104.62 | 870.92              | 1108.89 | 36926.037 | 5.7706     | 3.2172               |
| 33.4 | 104.93 | 876.16              | 1115.56 | 37259.704 | 5.7792     | 3.2204               |
| 33.5 | 105.24 | 881.41              | 1122.25 | 37595.375 | 5.7879     | 3.2237               |
| 33.6 | 105.56 | 886.68              | 1128.96 | 37933.056 | 5.7965     | 3.2269               |
| 33.7 | 105.87 | 891.97              | 1135.69 | 38272.753 | 5.8051     | 3.2301               |
| 33.8 | 106.19 | 897.27              | 1142.44 | 38614.472 | 5.8137     | 3.2332               |
| 33.9 | 106.50 | 902.59              | 1149.21 | 38958.219 | 5.8223     | 3.2364               |
| 34.0 | 106.81 | 907.92              | 1156.00 | 39304.000 | 5.8310     | 3.2396               |
| 34.1 | 107.13 | 913.27              | 1162.81 | 39651.821 | 5.8395     | 3.2428               |
| 34.2 | 107.44 | 918.63              | 1169.64 | 40001.688 | 5.8480     | 3.2460               |
| 34.3 | 107.76 | 924.01              | 1176.49 | 40353.607 | 5.8566     | 3.2491               |
| 34.4 | 108.07 | 929.41              | 1183.36 | 40707.584 | 5.8651     | 3.2522               |



## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$   | $n^3$     | $\sqrt{n}$ | $\frac{2}{\sqrt{n}}$ |
|------|--------|---------------------|---------|-----------|------------|----------------------|
| 34.5 | 108.38 | 934.82              | 1190.25 | 41063.625 | 5.8730     | 3.2554               |
| 34.6 | 108.70 | 940.25              | 1197.16 | 41421.736 | 5.8821     | 3.2586               |
| 34.7 | 109.01 | 945.69              | 1204.09 | 41781.923 | 5.8906     | 3.2617               |
| 34.8 | 109.33 | 951.15              | 1211.04 | 42144.192 | 5.8991     | 3.2648               |
| 34.9 | 109.64 | 956.62              | 1218.01 | 42508.549 | 5.9076     | 3.2679               |
| 35.0 | 109.96 | 962.11              | 1225.00 | 42875.000 | 5.9161     | 3.2710               |
| 35.1 | 110.27 | 967.62              | 1232.01 | 43243.551 | 5.9245     | 3.2742               |
| 35.2 | 110.58 | 973.14              | 1239.04 | 43614.208 | 5.9329     | 3.2773               |
| 35.3 | 110.90 | 978.68              | 1246.09 | 43986.977 | 5.9413     | 3.2804               |
| 35.4 | 111.21 | 984.23              | 1253.16 | 44361.864 | 5.9497     | 3.2835               |
| 35.5 | 111.53 | 989.80              | 1260.25 | 44738.875 | 5.9581     | 3.2866               |
| 35.6 | 111.84 | 995.38              | 1267.36 | 45118.016 | 5.9665     | 3.2897               |
| 35.7 | 112.15 | 1000.98             | 1274.49 | 45499.293 | 5.9749     | 3.2927               |
| 35.8 | 112.47 | 1006.60             | 1281.64 | 45882.712 | 5.9833     | 3.2958               |
| 35.9 | 112.78 | 1012.23             | 1288.81 | 46268.279 | 5.9916     | 3.2989               |
| 36.0 | 113.10 | 1017.88             | 1296.00 | 46656.000 | 6.0000     | 3.3019               |
| 36.1 | 113.41 | 1023.54             | 1303.21 | 47045.881 | 6.0083     | 3.3050               |
| 36.2 | 113.73 | 1029.22             | 1310.44 | 47437.928 | 6.0166     | 3.3080               |
| 36.3 | 114.04 | 1034.91             | 1317.69 | 47832.147 | 6.0249     | 3.3111               |
| 36.4 | 114.35 | 1040.62             | 1324.96 | 48228.544 | 6.0332     | 3.3141               |
| 36.5 | 114.67 | 1046.35             | 1332.25 | 48627.125 | 6.0415     | 3.3171               |
| 36.6 | 114.98 | 1052.09             | 1339.56 | 49027.896 | 6.0497     | 3.3202               |
| 36.7 | 115.30 | 1057.84             | 1346.89 | 49430.863 | 6.0580     | 3.3232               |
| 36.8 | 115.61 | 1063.62             | 1354.24 | 49836.032 | 6.0663     | 3.3262               |
| 36.9 | 115.92 | 1069.41             | 1361.61 | 50243.409 | 6.0745     | 3.3292               |
| 37.0 | 116.24 | 1075.21             | 1369.00 | 50653.000 | 6.0827     | 3.3322               |
| 37.1 | 116.55 | 1081.03             | 1376.41 | 51064.811 | 6.0909     | 3.3352               |
| 37.2 | 116.87 | 1086.87             | 1383.84 | 51478.848 | 6.0991     | 3.3382               |
| 37.3 | 117.18 | 1092.72             | 1391.29 | 51895.117 | 6.1073     | 3.3412               |
| 37.4 | 117.50 | 1098.58             | 1398.76 | 52313.624 | 6.1155     | 3.3442               |
| 37.5 | 117.81 | 1104.47             | 1406.25 | 52734.375 | 6.1237     | 3.3472               |
| 37.6 | 118.12 | 1110.36             | 1413.76 | 53157.376 | 6.1318     | 3.3501               |
| 37.7 | 118.44 | 1116.28             | 1421.29 | 53582.633 | 6.1400     | 3.3531               |
| 37.8 | 118.75 | 1122.21             | 1428.84 | 54010.152 | 6.1481     | 3.3561               |
| 37.9 | 119.07 | 1128.15             | 1436.41 | 54439.939 | 6.1563     | 3.3590               |
| 38.0 | 119.38 | 1134.11             | 1444.00 | 54872.000 | 6.1644     | 3.3620               |
| 38.1 | 119.69 | 1140.09             | 1451.61 | 55306.341 | 6.1725     | 3.3649               |
| 38.2 | 120.01 | 1146.08             | 1459.24 | 55742.968 | 6.1806     | 3.3679               |
| 38.3 | 120.32 | 1152.09             | 1466.89 | 56181.887 | 6.1887     | 3.3708               |
| 38.4 | 120.64 | 1158.12             | 1474.56 | 56623.104 | 6.1967     | 3.3737               |
| 38.5 | 120.95 | 1164.16             | 1482.25 | 57066.625 | 6.2048     | 3.3767               |
| 38.6 | 121.27 | 1170.21             | 1489.96 | 57512.456 | 6.2129     | 3.3796               |
| 38.7 | 121.58 | 1176.28             | 1497.69 | 57960.603 | 6.2209     | 3.3825               |

## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$   | $n^3$     | $\sqrt{n}$ | $\sqrt[3]{n}$ |
|------|--------|---------------------|---------|-----------|------------|---------------|
| 38.8 | 121.89 | 1182.37             | 1505.44 | 58411.072 | 6.2289     | 3.3854        |
| 38.9 | 122.21 | 1188.47             | 1513.21 | 58863.869 | 6.2370     | 3.3883        |
| 39.0 | 122.52 | 1194.59             | 1521.00 | 59319.000 | 6.2450     | 3.3912        |
| 39.1 | 122.84 | 1200.72             | 1528.81 | 59776.471 | 6.2530     | 3.3941        |
| 39.2 | 123.15 | 1206.87             | 1536.64 | 60236.288 | 6.2610     | 3.3970        |
| 39.3 | 123.46 | 1213.04             | 1544.49 | 60698.457 | 6.2689     | 3.3999        |
| 39.4 | 123.78 | 1219.22             | 1552.36 | 61162.984 | 6.2769     | 3.4028        |
| 39.5 | 124.09 | 1225.42             | 1560.25 | 61629.875 | 6.2849     | 3.4056        |
| 39.6 | 124.41 | 1231.63             | 1568.16 | 62099.136 | 6.2928     | 3.4085        |
| 39.7 | 124.72 | 1237.86             | 1576.09 | 62570.773 | 6.3008     | 3.4114        |
| 39.8 | 125.04 | 1244.10             | 1584.04 | 63044.792 | 6.3087     | 3.4142        |
| 39.9 | 125.35 | 1250.36             | 1592.01 | 63521.199 | 6.3166     | 3.4171        |
| 40.0 | 125.66 | 1256.64             | 1600.00 | 64000.000 | 6.3245     | 3.4200        |
| 40.1 | 125.98 | 1262.93             | 1608.01 | 64481.201 | 6.3325     | 3.4228        |
| 40.2 | 126.29 | 1269.23             | 1616.04 | 64964.808 | 6.3404     | 3.4256        |
| 40.3 | 126.61 | 1275.56             | 1624.09 | 65450.827 | 6.3482     | 3.4285        |
| 40.4 | 126.92 | 1281.90             | 1632.16 | 65939.264 | 6.3561     | 3.4313        |
| 40.5 | 127.23 | 1288.25             | 1640.25 | 66430.125 | 6.3639     | 3.4341        |
| 40.6 | 127.55 | 1294.62             | 1648.36 | 66923.416 | 6.3718     | 3.4370        |
| 40.7 | 127.86 | 1301.00             | 1656.49 | 67419.143 | 6.3796     | 3.4398        |
| 40.8 | 128.18 | 1307.41             | 1664.64 | 67911.312 | 6.3875     | 3.4426        |
| 40.9 | 128.49 | 1313.82             | 1672.81 | 68417.929 | 6.3953     | 3.4454        |
| 41.0 | 128.81 | 1320.25             | 1681.00 | 68921.000 | 6.4031     | 3.4482        |
| 41.1 | 129.12 | 1326.70             | 1689.21 | 69426.531 | 6.4109     | 3.4510        |
| 41.2 | 129.43 | 1333.17             | 1697.44 | 69934.528 | 6.4187     | 3.4538        |
| 41.3 | 129.75 | 1339.65             | 1705.69 | 70444.997 | 6.4265     | 3.4566        |
| 41.4 | 130.06 | 1346.14             | 1713.96 | 70957.944 | 6.4343     | 3.4594        |
| 41.5 | 130.38 | 1352.65             | 1722.25 | 71473.375 | 6.4421     | 3.4622        |
| 41.6 | 130.69 | 1359.18             | 1730.56 | 71991.296 | 6.4498     | 3.4650        |
| 41.7 | 131.00 | 1365.72             | 1738.89 | 72511.713 | 6.4575     | 3.4677        |
| 41.8 | 131.32 | 1372.28             | 1747.24 | 73034.632 | 6.4653     | 3.4705        |
| 41.9 | 131.63 | 1378.85             | 1755.61 | 73560.059 | 6.4730     | 3.4733        |
| 42.0 | 131.95 | 1385.44             | 1764.00 | 74088.000 | 6.4807     | 3.4760        |
| 42.1 | 132.26 | 1392.05             | 1772.41 | 74618.461 | 6.4884     | 3.4788        |
| 42.2 | 132.58 | 1398.67             | 1780.84 | 75151.448 | 6.4961     | 3.4815        |
| 42.3 | 132.89 | 1405.31             | 1789.29 | 75686.967 | 6.5038     | 3.4843        |
| 42.4 | 133.20 | 1411.96             | 1797.76 | 76225.024 | 6.5115     | 3.4870        |
| 42.5 | 133.52 | 1418.63             | 1806.25 | 76765.625 | 6.5192     | 3.4898        |
| 42.6 | 133.83 | 1425.31             | 1814.76 | 77308.776 | 6.5268     | 3.4925        |
| 42.7 | 134.15 | 1432.01             | 1823.29 | 77854.483 | 6.5345     | 3.4952        |
| 42.8 | 134.46 | 1438.72             | 1831.84 | 78402.752 | 6.5422     | 3.4980        |
| 42.9 | 134.77 | 1445.45             | 1840.41 | 78953.589 | 6.5498     | 3.5007        |

## CONSTANTS—Continued.

| $n$  | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$   | $n^3$      | $\sqrt{n}$ | $\sqrt[3]{n}$ |
|------|--------|---------------------|---------|------------|------------|---------------|
| 43.0 | 135.09 | 1452.20             | 1849.00 | 79507.000  | 6.5574     | 3.5034        |
| 43.1 | 135.40 | 1458.96             | 1857.61 | 80062.991  | 6.5651     | 3.5061        |
| 43.2 | 135.72 | 1465.74             | 1866.24 | 80621.568  | 6.5727     | 3.5088        |
| 43.3 | 136.03 | 1472.54             | 1874.89 | 81182.737  | 6.5803     | 3.5115        |
| 43.4 | 136.35 | 1479.34             | 1883.56 | 81746.504  | 6.5879     | 3.5142        |
| 43.5 | 136.66 | 1486.17             | 1892.25 | 82312.875  | 6.5954     | 3.5169        |
| 43.6 | 136.97 | 1493.01             | 1900.96 | 82881.856  | 6.6030     | 3.5196        |
| 43.7 | 137.29 | 1499.87             | 1909.69 | 83453.453  | 6.6106     | 3.5223        |
| 43.8 | 137.60 | 1506.74             | 1918.44 | 84027.672  | 6.6182     | 3.5250        |
| 43.9 | 137.92 | 1513.63             | 1927.21 | 84604.519  | 6.6257     | 3.5277        |
| 44.0 | 138.23 | 1520.53             | 1936.00 | 85184.000  | 6.6333     | 3.5303        |
| 44.1 | 138.54 | 1527.45             | 1944.81 | 85766.121  | 6.6408     | 3.5330        |
| 44.2 | 138.86 | 1534.39             | 1953.64 | 86350.888  | 6.6483     | 3.5357        |
| 44.3 | 139.17 | 1541.34             | 1962.49 | 86938.307  | 6.6558     | 3.5384        |
| 44.4 | 139.49 | 1548.30             | 1971.36 | 87528.384  | 6.6633     | 3.5410        |
| 44.5 | 139.80 | 1555.28             | 1980.25 | 88121.125  | 6.6708     | 3.5437        |
| 44.6 | 140.12 | 1562.28             | 1989.16 | 88716.536  | 6.6783     | 3.5463        |
| 44.7 | 140.43 | 1569.30             | 1998.09 | 89314.623  | 6.6858     | 3.5490        |
| 44.8 | 140.74 | 1576.33             | 2007.04 | 89915.392  | 6.6933     | 3.5516        |
| 44.9 | 141.06 | 1583.37             | 2016.01 | 90518.849  | 6.7007     | 3.5543        |
| 45.0 | 141.37 | 1590.43             | 2025.00 | 91125.000  | 6.7082     | 3.5569        |
| 45.1 | 141.69 | 1597.51             | 2034.01 | 91733.851  | 6.7156     | 3.5595        |
| 45.2 | 142.00 | 1604.60             | 2043.04 | 92345.408  | 6.7231     | 3.5621        |
| 45.3 | 142.31 | 1611.71             | 2052.09 | 92959.677  | 6.7305     | 3.5648        |
| 45.4 | 142.63 | 1618.83             | 2061.16 | 93576.664  | 6.7379     | 3.5674        |
| 45.5 | 142.94 | 1625.97             | 2070.25 | 94196.375  | 6.7454     | 3.5700        |
| 45.6 | 143.26 | 1633.13             | 2079.36 | 94818.816  | 6.7528     | 3.5726        |
| 45.7 | 143.57 | 1640.30             | 2088.49 | 95443.993  | 6.7602     | 3.5752        |
| 45.8 | 143.88 | 1647.48             | 2097.64 | 96071.912  | 6.7676     | 3.5778        |
| 45.9 | 144.20 | 1654.68             | 2106.81 | 96702.579  | 6.7749     | 3.5805        |
| 46.0 | 144.51 | 1661.90             | 2116.00 | 97336.000  | 6.7823     | 3.5830        |
| 46.1 | 144.83 | 1669.14             | 2125.21 | 97972.181  | 6.7897     | 3.5856        |
| 46.2 | 145.14 | 1676.39             | 2134.44 | 98611.128  | 6.7971     | 3.5882        |
| 46.3 | 145.46 | 1683.65             | 2143.69 | 99252.847  | 6.8044     | 3.5908        |
| 46.4 | 145.77 | 1690.93             | 2152.96 | 99897.344  | 6.8117     | 3.5934        |
| 46.5 | 146.08 | 1698.23             | 2162.25 | 100544.625 | 6.8191     | 3.5960        |
| 46.6 | 146.40 | 1705.54             | 2171.56 | 101194.696 | 6.8264     | 3.5986        |
| 46.7 | 146.71 | 1712.87             | 2180.89 | 101847.563 | 6.8337     | 3.6011        |
| 46.8 | 147.03 | 1720.21             | 2190.24 | 102503.232 | 6.8410     | 3.6037        |
| 46.9 | 147.34 | 1727.57             | 2199.61 | 103161.709 | 6.8484     | 3.6063        |
| 47.0 | 147.65 | 1734.94             | 2209.00 | 103823.000 | 6.8556     | 3.6088        |
| 47.1 | 147.97 | 1742.34             | 2218.41 | 104487.111 | 6.8629     | 3.6114        |
| 47.2 | 148.28 | 1749.74             | 2227.84 | 105154.048 | 6.8702     | 3.6139        |



CONSTANTS—Continued.

| $n$  | $n\pi$ | $\frac{n^2\pi}{4}$ | $n^2$   | $n^3$      | $\sqrt{n}$ | $\sqrt[3]{n}$ |
|------|--------|--------------------|---------|------------|------------|---------------|
| 47.3 | 148.60 | 1757.16            | 2237.29 | 105823.817 | 6.8775     | 3.6165        |
| 47.4 | 148.91 | 1764.60            | 2246.76 | 106496.424 | 6.8847     | 3.6190        |
| 47.5 | 149.23 | 1772.05            | 2256.25 | 107171.875 | 6.8920     | 3.6216        |
| 47.6 | 149.54 | 1779.52            | 2265.76 | 107850.176 | 6.8993     | 3.6241        |
| 47.7 | 149.85 | 1787.01            | 2275.29 | 108531.333 | 6.9065     | 3.6267        |
| 47.8 | 150.17 | 1794.51            | 2284.84 | 109215.352 | 6.9137     | 3.6292        |
| 47.9 | 150.48 | 1802.03            | 2294.41 | 109902.239 | 6.9209     | 3.6317        |
| 48.0 | 150.80 | 1809.56            | 2304.00 | 110592.000 | 6.9282     | 3.6342        |
| 48.1 | 151.11 | 1817.11            | 2313.61 | 111284.641 | 6.9354     | 3.6368        |
| 48.2 | 151.42 | 1824.67            | 2323.24 | 111980.168 | 6.9426     | 3.6393        |
| 48.3 | 151.74 | 1832.25            | 2332.89 | 112678.587 | 6.9498     | 3.6418        |
| 48.4 | 152.05 | 1839.84            | 2342.56 | 113379.904 | 6.9570     | 3.6443        |
| 48.5 | 152.37 | 1847.45            | 2352.25 | 114084.125 | 6.9642     | 3.6468        |
| 48.6 | 152.68 | 1855.08            | 2361.96 | 114791.256 | 6.9714     | 3.6493        |
| 48.7 | 153.00 | 1862.72            | 2371.69 | 115501.303 | 6.9785     | 3.6518        |
| 48.8 | 153.31 | 1870.38            | 2381.44 | 116214.272 | 6.9857     | 3.6543        |
| 48.9 | 153.62 | 1878.05            | 2391.21 | 116930.169 | 6.9928     | 3.6568        |
| 49.0 | 153.94 | 1885.74            | 2401.00 | 117649.000 | 7.0000     | 3.6593        |
| 49.1 | 154.25 | 1893.45            | 2410.81 | 118370.771 | 7.0071     | 3.6618        |
| 49.2 | 154.57 | 1901.17            | 2420.64 | 119095.488 | 7.0143     | 3.6643        |
| 49.3 | 154.88 | 1908.90            | 2430.49 | 119823.157 | 7.0214     | 3.6668        |
| 49.4 | 155.19 | 1916.65            | 2440.36 | 120553.784 | 7.0285     | 3.6692        |
| 49.5 | 155.51 | 1924.42            | 2450.25 | 121287.375 | 7.0356     | 3.6717        |
| 49.6 | 155.82 | 1932.21            | 2460.16 | 122023.936 | 7.0427     | 3.6742        |
| 49.7 | 156.14 | 1940.00            | 2470.09 | 122763.473 | 7.0498     | 3.6767        |
| 49.8 | 156.45 | 1947.82            | 2480.04 | 123505.992 | 7.0569     | 3.6791        |
| 49.9 | 156.77 | 1955.65            | 2490.01 | 124251.499 | 7.0640     | 3.6816        |
| 50.0 | 157.08 | 1963.50            | 2500.00 | 125000.000 | 7.0711     | 3.6840        |
| 51.0 | 160.22 | 2042.82            | 2601.00 | 132651.000 | 7.1414     | 3.7084        |
| 52.0 | 163.36 | 2123.72            | 2704.00 | 140608.000 | 7.2111     | 3.7325        |
| 53.0 | 166.50 | 2206.19            | 2809.00 | 148877.000 | 7.2801     | 3.7563        |
| 54.0 | 169.64 | 2290.22            | 2916.00 | 157464.000 | 7.3485     | 3.7798        |
| 55.0 | 172.78 | 2375.83            | 3025.00 | 166375.000 | 7.4162     | 3.8030        |
| 56.0 | 175.93 | 2463.01            | 3136.00 | 175616.000 | 7.4833     | 3.8259        |
| 57.0 | 179.07 | 2551.76            | 3249.00 | 185193.000 | 7.5498     | 3.8485        |
| 58.0 | 182.21 | 2642.08            | 3364.00 | 195112.000 | 7.6158     | 3.8709        |
| 59.0 | 185.35 | 2733.77            | 3481.00 | 205379.000 | 7.6811     | 3.8930        |
| 60.0 | 188.49 | 2827.44            | 3600.00 | 216000.000 | 7.7460     | 3.9149        |
| 61.0 | 191.63 | 2922.47            | 3721.00 | 226981.000 | 7.8102     | 3.9365        |
| 62.0 | 194.77 | 3019.07            | 3844.00 | 238328.000 | 7.8740     | 3.9579        |
| 63.0 | 197.92 | 3117.25            | 3969.00 | 250047.000 | 7.9373     | 3.9791        |
| 64.0 | 201.06 | 3216.99            | 4096.00 | 262144.000 | 8.0000     | 4.0000        |
| 65.0 | 204.20 | 3318.31            | 4225.00 | 274625.000 | 8.0623     | 4.0207        |
| 66.0 | 207.34 | 3421.20            | 4356.00 | 287496.000 | 8.1240     | 4.0412        |



## CONSTANTS—Continued.

| $n$   | $n\pi$ | $n^2 \frac{\pi}{4}$ | $n^2$    | $n^3$       | $\sqrt{n}$ | $\frac{3}{\sqrt{n}}$ |
|-------|--------|---------------------|----------|-------------|------------|----------------------|
| 67.0  | 210.48 | 3525.66             | 4489.00  | 300763.000  | 8.1854     | 4.0615               |
| 68.0  | 213.63 | 3631.69             | 4624.00  | 314432.000  | 8.2462     | 4.0817               |
| 69.0  | 216.77 | 3739.29             | 4761.00  | 328509.000  | 8.3066     | 4.1016               |
| 70.0  | 219.91 | 3848.46             | 4900.00  | 343000.000  | 8.3666     | 4.1213               |
| 71.0  | 223.05 | 3959.20             | 5041.00  | 357911.000  | 8.4261     | 4.1408               |
| 72.0  | 226.19 | 4071.51             | 5184.00  | 373248.000  | 8.4853     | 4.1602               |
| 73.0  | 229.33 | 4185.39             | 5329.00  | 389017.000  | 8.5440     | 4.1793               |
| 74.0  | 232.47 | 4300.85             | 5476.00  | 405224.000  | 8.6023     | 4.1983               |
| 75.0  | 235.62 | 4417.87             | 5625.00  | 421875.000  | 8.6603     | 4.2172               |
| 76.0  | 238.76 | 4536.47             | 5776.00  | 438976.000  | 8.7178     | 4.2358               |
| 77.0  | 241.90 | 4656.63             | 5929.00  | 456533.000  | 8.7750     | 4.2543               |
| 78.0  | 245.04 | 4778.37             | 6084.00  | 474552.000  | 8.8318     | 4.2727               |
| 79.0  | 248.18 | 4901.68             | 6241.00  | 493039.000  | 8.8882     | 4.2908               |
| 80.0  | 251.32 | 5026.56             | 6400.00  | 512000.000  | 8.9443     | 4.3089               |
| 81.0  | 254.47 | 5153.01             | 6561.00  | 531441.000  | 9.0000     | 4.3267               |
| 82.0  | 257.61 | 5281.03             | 6724.00  | 551368.000  | 9.0554     | 4.3445               |
| 83.0  | 260.75 | 5410.62             | 6889.00  | 571787.000  | 9.1104     | 4.3621               |
| 84.0  | 263.89 | 5541.78             | 7056.00  | 592704.000  | 9.1652     | 4.3795               |
| 85.0  | 267.03 | 5674.50             | 7225.00  | 614125.000  | 9.2195     | 4.3968               |
| 86.0  | 270.17 | 5808.81             | 7396.00  | 636056.000  | 9.2736     | 4.4140               |
| 87.0  | 273.32 | 5944.69             | 7569.00  | 658503.000  | 9.3274     | 4.4310               |
| 88.0  | 276.46 | 6082.13             | 7744.00  | 681472.000  | 9.3808     | 4.4480               |
| 89.0  | 279.60 | 6221.13             | 7921.00  | 704969.000  | 9.4340     | 4.4647               |
| 90.0  | 282.74 | 6361.74             | 8100.00  | 729000.000  | 9.4868     | 4.4814               |
| 91.0  | 285.88 | 6503.89             | 8281.00  | 753571.000  | 9.5394     | 4.4979               |
| 92.0  | 289.02 | 6647.62             | 8464.00  | 778688.000  | 9.5917     | 4.5144               |
| 93.0  | 292.17 | 6792.92             | 8649.00  | 804357.000  | 9.6437     | 4.5307               |
| 94.0  | 295.31 | 6939.78             | 8836.00  | 830584.000  | 9.6954     | 4.5468               |
| 95.0  | 298.45 | 7088.23             | 9025.00  | 857375.000  | 9.7468     | 4.5629               |
| 96.0  | 301.59 | 7238.24             | 9216.00  | 884736.000  | 9.7980     | 4.5789               |
| 97.0  | 304.73 | 7389.83             | 9409.00  | 912673.000  | 9.8489     | 4.5947               |
| 98.0  | 307.87 | 7542.98             | 9604.00  | 941192.000  | 9.8995     | 4.6104               |
| 99.0  | 311.02 | 7697.68             | 9801.00  | 970299.000  | 9.9499     | 4.6261               |
| 100.0 | 314.16 | 7854.00             | 10000.00 | 1000000.000 | 10.0000    | 4.6416               |

II.  
LOGARITHMS.  
HYPERBOLIC LOGARITHMS.

| N.   | Log.   | N.   | Log.   | N.   | Log.   | N.   | Log.   | N.    | Log.   |
|------|--------|------|--------|------|--------|------|--------|-------|--------|
| 1.00 | 0.0000 | 2.30 | 0.8329 | 3.60 | 1.2809 | 4.90 | 1.5892 | 6.40  | 1.8563 |
| 1.05 | 0.0488 | 2.35 | 0.8544 | 3.65 | 1.2947 | 4.95 | 1.5994 | 6.50  | 1.8718 |
| 1.10 | 0.0953 | 2.40 | 0.8755 | 3.70 | 1.3083 | 5.00 | 1.6094 | 6.60  | 1.8871 |
| 1.15 | 0.1398 | 2.45 | 0.8961 | 3.75 | 1.3218 | 5.05 | 1.6194 | 6.70  | 1.9021 |
| 1.20 | 0.1823 | 2.50 | 0.9163 | 3.80 | 1.3350 | 5.10 | 1.6292 | 6.80  | 1.9169 |
| 1.25 | 0.2231 | 2.55 | 0.9361 | 3.85 | 1.3481 | 5.15 | 1.6390 | 6.90  | 1.9315 |
| 1.30 | 0.2624 | 2.60 | 0.9555 | 3.90 | 1.3610 | 5.20 | 1.6487 | 7.00  | 1.9459 |
| 1.35 | 0.3001 | 2.65 | 0.9746 | 3.95 | 1.3737 | 5.25 | 1.6582 | 7.20  | 1.9741 |
| 1.40 | 0.3365 | 2.70 | 0.9933 | 4.00 | 1.3863 | 5.30 | 1.6677 | 7.40  | 2.0015 |
| 1.45 | 0.3716 | 2.75 | 1.0116 | 4.05 | 1.3987 | 5.35 | 1.6771 | 7.60  | 2.0281 |
| 1.50 | 0.4055 | 2.80 | 1.0296 | 4.10 | 1.4110 | 5.40 | 1.6864 | 7.80  | 2.0541 |
| 1.55 | 0.4383 | 2.85 | 1.0473 | 4.15 | 1.4231 | 5.45 | 1.6956 | 8.00  | 2.0794 |
| 1.60 | 0.4700 | 2.90 | 1.0647 | 4.20 | 1.4351 | 5.50 | 1.7047 | 8.25  | 2.1102 |
| 1.65 | 0.5008 | 2.95 | 1.0818 | 4.25 | 1.4469 | 5.55 | 1.7138 | 8.50  | 2.1401 |
| 1.70 | 0.5306 | 3.00 | 1.0986 | 4.30 | 1.4586 | 5.60 | 1.7228 | 8.75  | 2.1691 |
| 1.75 | 0.5596 | 3.05 | 1.1154 | 4.35 | 1.4701 | 5.65 | 1.7317 | 9.00  | 2.1972 |
| 1.80 | 0.5878 | 3.10 | 1.1314 | 4.40 | 1.4816 | 5.70 | 1.7405 | 9.25  | 2.2246 |
| 1.85 | 0.6152 | 3.15 | 1.1474 | 4.45 | 1.4929 | 5.75 | 1.7492 | 9.50  | 2.2513 |
| 1.90 | 0.6419 | 3.20 | 1.1632 | 4.50 | 1.5041 | 5.80 | 1.7579 | 9.75  | 2.2773 |
| 1.95 | 0.6678 | 3.25 | 1.1787 | 4.55 | 1.5151 | 5.85 | 1.7664 | 10.00 | 2.3026 |
| 2.00 | 0.6931 | 3.30 | 1.1939 | 4.60 | 1.5261 | 5.90 | 1.7750 | 11.00 | 2.3979 |
| 2.05 | 0.7178 | 3.35 | 1.2090 | 4.65 | 1.5369 | 5.95 | 1.7834 | 12.00 | 2.4849 |
| 2.10 | 0.7419 | 3.40 | 1.2238 | 4.70 | 1.5476 | 6.00 | 1.7918 | 13.00 | 2.5649 |
| 2.15 | 0.7655 | 3.45 | 1.2384 | 4.75 | 1.5581 | 6.10 | 1.8003 | 14.00 | 2.6391 |
| 2.20 | 0.7885 | 3.50 | 1.2528 | 4.80 | 1.5686 | 6.20 | 1.8245 | 15.00 | 2.7081 |
| 2.25 | 0.8109 | 3.55 | 1.2669 | 4.85 | 1.5790 | 6.30 | 1.8405 | 16.00 | 2.7726 |

COMMON LOGARITHMS: 10-1200.

| N. | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | Diff. |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 10 | 00000 | 00432 | 00860 | 01284 | 01703 | 02119 | 02531 | 02938 | 03342 | 03743 | 396   |
| 11 | 04139 | 04532 | 04922 | 05308 | 05690 | 06070 | 06446 | 06819 | 07188 | 07555 | 363   |
| 12 | 07918 | 08279 | 08636 | 08991 | 09342 | 09691 | 10037 | 10380 | 10721 | 11059 | 335   |
| 13 | 11394 | 11727 | 12057 | 12385 | 12710 | 13033 | 13354 | 13672 | 13988 | 14301 | 312   |
| 14 | 14613 | 14922 | 15229 | 15534 | 15836 | 16137 | 16435 | 16732 | 17026 | 17319 | 290   |
| 15 | 17609 | 17898 | 18184 | 18469 | 18752 | 19033 | 19312 | 19590 | 19866 | 20140 | 272   |
| 16 | 20412 | 20683 | 20952 | 21219 | 21484 | 21748 | 22011 | 22272 | 22531 | 22789 | 256   |
| 17 | 23045 | 23300 | 23553 | 23805 | 24055 | 24304 | 24551 | 24797 | 25042 | 25285 | 242   |
| 18 | 25227 | 25468 | 25707 | 25945 | 26182 | 26417 | 26651 | 26884 | 27116 | 27346 | 229   |
| 19 | 27875 | 28103 | 28330 | 28556 | 28780 | 29003 | 29226 | 29447 | 29667 | 29885 | 218   |
| 20 | 30103 | 30320 | 30535 | 30750 | 30963 | 31175 | 31387 | 31597 | 31806 | 32015 | 207   |
| 21 | 32222 | 32428 | 32634 | 32838 | 33041 | 33244 | 33445 | 33646 | 33846 | 34044 | 198   |
| 22 | 34242 | 34439 | 34635 | 34830 | 35025 | 35218 | 35411 | 35603 | 35793 | 35984 | 189   |
| 23 | 36173 | 36361 | 36549 | 36736 | 36922 | 37107 | 37291 | 37475 | 37658 | 37840 | 181   |
| 24 | 38021 | 38202 | 38382 | 38561 | 38739 | 38917 | 39094 | 39270 | 39445 | 39620 | 174.  |
| 25 | 39794 | 39967 | 40140 | 40312 | 40483 | 40654 | 40824 | 40993 | 41162 | 41330 | 167   |
| 26 | 41497 | 41664 | 41830 | 41996 | 42160 | 42325 | 42488 | 42651 | 42813 | 42975 | 161   |
| 27 | 43136 | 43297 | 43457 | 43616 | 43775 | 43933 | 44091 | 44248 | 44404 | 44560 | 156.  |
| 28 | 44716 | 44871 | 45025 | 45179 | 45332 | 45484 | 45637 | 45788 | 45939 | 46090 | 150.  |
| 29 | 46240 | 46389 | 46538 | 46687 | 46835 | 46982 | 47129 | 47276 | 47422 | 47567 | 145.  |

## COMMON LOGARITHMS—Continued.

| N. | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | Diff. |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 30 | 47712 | 47857 | 48001 | 48144 | 48287 | 48430 | 48572 | 48714 | 48855 | 48996 | 140   |
| 31 | 49136 | 49276 | 49415 | 49554 | 49693 | 49831 | 49969 | 50106 | 50243 | 50379 | 136   |
| 32 | 50515 | 50651 | 50786 | 50920 | 51055 | 51188 | 51322 | 51455 | 51587 | 51720 | 132   |
| 33 | 51851 | 51983 | 52114 | 52244 | 52375 | 52504 | 52634 | 52763 | 52892 | 53020 | 128   |
| 34 | 53148 | 53275 | 53403 | 53529 | 53656 | 53782 | 53908 | 54033 | 54158 | 54283 | 124   |
| 35 | 54407 | 54531 | 54654 | 54777 | 54900 | 55023 | 55145 | 55267 | 55388 | 55509 | 121   |
| 36 | 55630 | 55751 | 55871 | 55991 | 56110 | 56229 | 56348 | 56467 | 56585 | 56703 | 117   |
| 37 | 56820 | 56937 | 57054 | 57171 | 57287 | 57403 | 57519 | 57634 | 57749 | 57864 | 114   |
| 38 | 57978 | 58092 | 58206 | 58320 | 58433 | 58546 | 58659 | 58771 | 58883 | 58995 | 111   |
| 39 | 59106 | 59218 | 59329 | 59439 | 59550 | 59660 | 59770 | 59879 | 59988 | 60097 | 109   |
| 40 | 60206 | 60314 | 60423 | 60531 | 60638 | 60746 | 60853 | 60959 | 61066 | 61172 | 106   |
| 41 | 61278 | 61384 | 61490 | 61595 | 61700 | 61805 | 61909 | 62014 | 62118 | 62221 | 104   |
| 42 | 62325 | 62428 | 62531 | 62634 | 62737 | 62839 | 62941 | 63043 | 63144 | 63246 | 101   |
| 43 | 63347 | 63448 | 63548 | 63649 | 63749 | 63849 | 63949 | 64048 | 64147 | 64246 | 99    |
| 44 | 64345 | 64444 | 64542 | 64640 | 64738 | 64836 | 64933 | 65031 | 65128 | 65225 | 97    |
| 45 | 65321 | 65418 | 65514 | 65610 | 65706 | 65801 | 65896 | 65992 | 66087 | 66181 | 95    |
| 46 | 66276 | 66370 | 66464 | 66558 | 66652 | 66745 | 66839 | 66932 | 67025 | 67117 | 93    |
| 47 | 67210 | 67302 | 67394 | 67486 | 67578 | 67669 | 67761 | 67852 | 67943 | 68034 | 90    |
| 48 | 68124 | 68215 | 68305 | 68395 | 68485 | 68574 | 68664 | 68753 | 68842 | 68931 | 89    |
| 49 | 69020 | 69108 | 69197 | 69285 | 69373 | 69461 | 69548 | 69636 | 69723 | 69810 | 87    |
| 50 | 69897 | 69984 | 70070 | 70157 | 70243 | 70329 | 70415 | 70501 | 70586 | 70672 | 86    |
| 51 | 70757 | 70842 | 70927 | 71012 | 71096 | 71181 | 71265 | 71349 | 71433 | 71517 | 84    |
| 52 | 71600 | 71684 | 71767 | 71850 | 71933 | 72016 | 72099 | 72181 | 72263 | 72346 | 81    |
| 53 | 72428 | 72509 | 72591 | 72673 | 72754 | 72835 | 72916 | 72997 | 73078 | 73159 | 83    |
| 54 | 73239 | 73320 | 73400 | 73480 | 73560 | 73640 | 73719 | 73799 | 73878 | 73957 | 80    |
| 55 | 74036 | 74115 | 74194 | 74273 | 74351 | 74429 | 74507 | 74586 | 74663 | 74741 | 78    |
| 56 | 74819 | 74896 | 74974 | 75051 | 75128 | 75205 | 75282 | 75358 | 75435 | 75511 | 77    |
| 57 | 75587 | 75664 | 75740 | 75815 | 75891 | 75967 | 76042 | 76118 | 76193 | 76268 | 76    |
| 58 | 76343 | 76418 | 76492 | 76567 | 76641 | 76716 | 76790 | 76864 | 76938 | 77012 | 74    |
| 59 | 77085 | 77159 | 77232 | 77305 | 77379 | 77452 | 77525 | 77597 | 77670 | 77743 | 73    |
| 60 | 77815 | 77887 | 77960 | 78032 | 78104 | 78176 | 78247 | 78319 | 78390 | 78462 | 72    |
| 61 | 78533 | 78604 | 78675 | 78746 | 78817 | 78888 | 78958 | 79029 | 79099 | 79169 | 71    |
| 62 | 79239 | 79309 | 79379 | 79449 | 79518 | 79588 | 79657 | 79727 | 79796 | 79865 | 69    |
| 63 | 79934 | 80003 | 80072 | 80140 | 80209 | 80277 | 80346 | 80414 | 80482 | 80550 | 68    |
| 64 | 80618 | 80686 | 80754 | 80821 | 80889 | 80956 | 81023 | 81090 | 81158 | 81224 | 67    |
| 65 | 81291 | 81358 | 81425 | 81491 | 81558 | 81624 | 81690 | 81757 | 81823 | 81889 | 66    |
| 66 | 81954 | 82020 | 82086 | 82151 | 82217 | 82282 | 82347 | 82413 | 82478 | 82543 | 65    |
| 67 | 82607 | 82672 | 82737 | 82802 | 82866 | 82930 | 82995 | 83059 | 83123 | 83187 | 64    |
| 68 | 83251 | 83315 | 83378 | 83442 | 83506 | 83569 | 83632 | 83696 | 83759 | 83822 | 63    |
| 69 | 83885 | 83948 | 84011 | 84073 | 84136 | 84198 | 84261 | 84323 | 84386 | 84448 | 63    |
| 70 | 84510 | 84572 | 84634 | 84696 | 84757 | 84819 | 84880 | 84942 | 85003 | 85065 | 62    |
| 71 | 85126 | 85187 | 85248 | 85309 | 85370 | 85431 | 85491 | 85552 | 85613 | 85673 | 61    |
| 72 | 85733 | 85794 | 85854 | 85914 | 85974 | 86034 | 86094 | 86153 | 86213 | 86273 | 60    |
| 73 | 86332 | 86392 | 86451 | 86510 | 86570 | 86629 | 86688 | 86747 | 86806 | 86864 | 59    |
| 74 | 86923 | 86982 | 87040 | 87099 | 87157 | 87216 | 87274 | 87332 | 87390 | 87448 | 58    |
| 75 | 87506 | 87564 | 87622 | 87679 | 87737 | 87795 | 87852 | 87910 | 87967 | 88024 | 58    |
| 76 | 88081 | 88138 | 88195 | 88252 | 88309 | 88366 | 88423 | 88480 | 88536 | 88593 | 57    |
| 77 | 88649 | 88705 | 88762 | 88818 | 88874 | 88930 | 88986 | 89042 | 89098 | 89154 | 56    |
| 78 | 89209 | 89265 | 89321 | 89376 | 89432 | 89487 | 89542 | 89597 | 89653 | 89708 | 55    |
| 79 | 89763 | 89818 | 89873 | 89927 | 89982 | 90037 | 90091 | 90146 | 90200 | 90255 | 55    |
| 80 | 90309 | 90363 | 90417 | 90472 | 90526 | 90580 | 90634 | 90687 | 90741 | 90795 | 54    |
| 81 | 90849 | 90902 | 90956 | 91009 | 91062 | 91116 | 91169 | 91222 | 91275 | 91328 | 53    |
| 82 | 91381 | 91434 | 91487 | 91540 | 91593 | 91645 | 91698 | 91751 | 91803 | 91855 | 52    |
| 83 | 91908 | 91960 | 92012 | 92065 | 92117 | 92169 | 92221 | 92273 | 92324 | 92376 | 52    |
| 84 | 92428 | 92480 | 92531 | 92583 | 92634 | 92686 | 92737 | 92788 | 92840 | 92891 | 51    |
| 85 | 92942 | 92993 | 93044 | 93095 | 93146 | 93197 | 93247 | 93298 | 93349 | 93399 | 51    |
| 86 | 93450 | 93500 | 93551 | 93601 | 93651 | 93702 | 93752 | 93802 | 93852 | 93902 | 50    |
| 87 | 93952 | 94002 | 94052 | 94101 | 94151 | 94201 | 94250 | 94300 | 94349 | 94399 | 50    |



COMMON LOGARITHMS—Continued.

| N.  | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | Diff. |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 88  | 94448 | 94498 | 94547 | 94596 | 94645 | 94694 | 94743 | 94792 | 94841 | 94890 | 49    |
| 89  | 94939 | 94988 | 95036 | 95085 | 95134 | 95182 | 95231 | 95279 | 95328 | 95376 | 49    |
| 90  | 95424 | 95472 | 95521 | 95569 | 95617 | 95665 | 95713 | 95761 | 95809 | 95856 | 48    |
| 91  | 95904 | 95952 | 95999 | 96047 | 96095 | 96142 | 96190 | 96237 | 96284 | 96332 | 47    |
| 92  | 96379 | 96426 | 96473 | 96520 | 96567 | 96614 | 96661 | 96708 | 96755 | 96802 | 47    |
| 93  | 96848 | 96895 | 96942 | 96988 | 97035 | 97081 | 97128 | 97174 | 97220 | 97267 | 46    |
| 94  | 97313 | 97359 | 97405 | 97451 | 97497 | 97543 | 97589 | 97635 | 97681 | 97727 | 46    |
| 95  | 97772 | 97818 | 97864 | 97909 | 97955 | 98000 | 98046 | 98091 | 98137 | 98182 | 45    |
| 96  | 98227 | 98272 | 98318 | 98363 | 98408 | 98453 | 98498 | 98543 | 98588 | 98632 | 45    |
| 97  | 98677 | 98722 | 98767 | 98811 | 98856 | 98900 | 98945 | 98989 | 99034 | 99078 | 45    |
| 98  | 99123 | 99167 | 99211 | 99255 | 99300 | 99344 | 99388 | 99432 | 99476 | 99520 | 44    |
| 99  | 99564 | 99607 | 99651 | 99695 | 99739 | 99782 | 99826 | 99870 | 99913 | 99957 | 44    |
| 100 | 00000 | 00043 | 00087 | 00130 | 00173 | 00217 | 00260 | 00303 | 00346 | 00389 | 43    |
| 101 | 00432 | 00475 | 00518 | 00561 | 00604 | 00647 | 00689 | 00732 | 00775 | 00817 | 43    |
| 102 | 00860 | 00903 | 00945 | 00988 | 01030 | 01072 | 01115 | 01157 | 01199 | 01242 | 42    |
| 103 | 01284 | 01326 | 01368 | 01410 | 01452 | 01494 | 01536 | 01578 | 01620 | 01662 | 42    |
| 104 | 01703 | 01745 | 01787 | 01828 | 01870 | 01912 | 01953 | 01995 | 02036 | 02078 | 42    |
| 105 | 02119 | 02160 | 02202 | 02243 | 02284 | 02325 | 02366 | 02407 | 02449 | 02490 | 41    |
| 106 | 02531 | 02572 | 02612 | 02653 | 02694 | 02735 | 02776 | 02816 | 02857 | 02898 | 41    |
| 107 | 02938 | 02979 | 03019 | 03060 | 03100 | 03141 | 03181 | 03222 | 03262 | 03302 | 41    |
| 108 | 03342 | 03383 | 03423 | 03463 | 03503 | 03543 | 03583 | 03623 | 03663 | 03703 | 40    |
| 109 | 03743 | 03782 | 03822 | 03862 | 03902 | 03941 | 03981 | 04021 | 04060 | 04100 | 40    |
| 110 | 04139 | 04179 | 04218 | 04258 | 04297 | 04336 | 04376 | 04415 | 04454 | 04493 | 39    |
| 111 | 04532 | 04571 | 04610 | 04650 | 04689 | 04727 | 04766 | 04805 | 04844 | 04883 | 39    |
| 112 | 04922 | 04961 | 04999 | 05038 | 05077 | 05115 | 05154 | 05192 | 05231 | 05269 | 39    |
| 113 | 05308 | 05346 | 05385 | 05423 | 05461 | 05500 | 05538 | 05576 | 05614 | 05652 | 38    |
| 114 | 05690 | 05729 | 05767 | 05805 | 05843 | 05881 | 05918 | 05956 | 05994 | 06032 | 38    |
| 115 | 06070 | 06108 | 06145 | 06183 | 06221 | 06258 | 06296 | 06333 | 06371 | 06408 | 38    |
| 116 | 06446 | 06483 | 06521 | 06558 | 06595 | 06633 | 06670 | 06707 | 06744 | 06781 | 37    |
| 117 | 06819 | 06856 | 06893 | 06930 | 06967 | 07004 | 07041 | 07078 | 07115 | 07151 | 37    |
| 118 | 07188 | 07225 | 07262 | 07298 | 07335 | 07372 | 07408 | 07445 | 07482 | 07518 | 37    |
| 119 | 07555 | 07591 | 07628 | 07664 | 07700 | 07737 | 07773 | 07809 | 07846 | 07882 | 36    |

Log.

Base of Napierian logarithms, . . . . .  $e = 2.7182818$  0.4342945

Log.  $e =$  Modulus of common logarithms, . . . . .  $M = 0.4342945$  9.6377843 - 10.

## III.

## MEAN PRESSURES FOR VARIOUS METHODS OF EXPANSION.

Values of  $\frac{p_m}{p_1}$ . Adiabatic Expansion of Steam.

| Ratio of<br>Expansion. | Cut-off,<br>$\frac{1}{n}$ | PERCENTAGE OF STEAM AND VALUE OF $n$ . |       |       |       |       |       |       |       |
|------------------------|---------------------------|--|-------|-------|-------|-------|-------|-------|-------|
|                        |                           | 100                                    | 90    | 80    | 76    | 70    | 60    | 50    | 100   |
|                        |                           | 1.135                                  | 1.125 | 1.115 | 1.111 | 1.105 | 1.095 | 1.085 | 1.333 |
| 2                      | $\frac{1}{2}$             | .829                                   | .831  | .833  | .834  | .835  | .836  | .837  | .810  |
| 2 $\frac{1}{2}$        | $\frac{2}{3}$             | .785                                   | .787  | .788  | .789  | .790  | .791  | .793  | .754  |
| 2 $\frac{1}{2}$        | $\frac{2}{3}$             | .744                                   | .746  | .747  | .748  | .749  | .750  | .751  | .714  |
| 2 $\frac{2}{3}$        | $\frac{3}{4}$             | .707                                   | .708  | .710  | .711  | .712  | .713  | .714  | .675  |
| 3                      | $\frac{1}{3}$             | .675                                   | .676  | .677  | .678  | .679  | .681  | .683  | .639  |
| 3 $\frac{1}{2}$        | $\frac{2}{5}$             | .644                                   | .645  | .647  | .648  | .649  | .650  | .652  | .606  |
| 3 $\frac{1}{2}$        | $\frac{2}{5}$             | .633                                   | .635  | .636  | .637  | .639  | .641  | .643  | .600  |
| 3 $\frac{1}{2}$        | $\frac{2}{7}$             | .616                                   | .618  | .619  | .620  | .622  | .624  | .626  | .576  |
| 3 $\frac{2}{3}$        | $\frac{3}{5}$             | .591                                   | .592  | .593  | .594  | .595  | .596  | .598  | .552  |
| 4                      | $\frac{1}{4}$             | .567                                   | .568  | .570  | .572  | .573  | .574  | .576  | .523  |
| 4 $\frac{1}{2}$        | $\frac{2}{5}$             | .525                                   | .527  | .528  | .530  | .531  | .533  | .534  | .486  |
| 5                      | $\frac{1}{5}$             | .488                                   | .491  | .493  | .494  | .496  | .498  | .500  | .447  |
| 5 $\frac{1}{2}$        | $\frac{2}{7}$             | .458                                   | .460  | .462  | .463  | .465  | .467  | .470  | .417  |
| 6                      | $\frac{1}{6}$             | .432                                   | .434  | .435  | .437  | .439  | .441  | .443  | .390  |
| 6 $\frac{1}{2}$        | $\frac{2}{7}$             | .409                                   | .410  | .411  | .413  | .415  | .417  | .420  | .369  |
| 7                      | $\frac{1}{7}$             | .387                                   | .390  | .392  | .394  | .400  | .403  | .405  | .345  |
| 8                      | $\frac{1}{8}$             | .355                                   | .356  | .357  | .358  | .360  | .361  | .363  | .312  |
| 10                     | $\frac{1}{10}$            | .298                                   | .300  | .302  | .303  | .304  | .305  | .308  | .263  |
| 20                     | $\frac{1}{20}$            | .170                                   | .173  | .175  | .177  | .178  | .180  | .182  | .144  |
| 50                     | $\frac{1}{50}$            | .080                                   | .082  | .083  | .084  | .084  | .085  | .086  | .063  |
| 100                    | $\frac{1}{100}$           | .044                                   | .045  | .045  | .046  | .046  | .047  | .048  | .034  |

III.—(Continued.)

MEAN PRESSURES FOR VARIOUS METHODS OF EXPANSION.

Values of  $\frac{p_m}{p_1}$  for Steam, Air, Gas, and Mixtures.

| Ratio of Expansion, $r$ . | Point of cut-off, $\frac{1}{r}$ . | Steam Expanding, Dry and Saturated, $n$ , 1.046. | Moist Air in Compressors, $n$ , 1.20. | Steam and Leakage, Actual Engines. |             | Gas and Vapor in Gas-engine, $n$ , 1.60. | Gases.                  |                        |
|---------------------------|-----------------------------------|--|---------------------------------------|------------------------------------|-------------|--|-------------------------|------------------------|
|                           |                                   |  |                                       | $n$ , 0.50.                        | $n$ , 0.75. |  | Isothermal, $n$ , 1.00. | Adiabatic, $n$ , 1.41. |
|                           |                                   |  |                                       |                                    |             |  |                         |                        |
| 2                         | $\frac{1}{2}$                     | .841   | .825                                  | .914                               | .875        | .783                                     | .846                    | .801                   |
| 2½                        | $\frac{2}{3}$                     | .793   | .787                                  | .888                               | .844        | .733                                     | .804                    | .753                   |
| 2⅔                        | $\frac{3}{4}$                     | .760   | .745                                  | .866                               | .800        | .683                                     | .765                    | .707                   |
| 2¾                        | $\frac{4}{7}$                     | .717   | .700                                  | .846                               | .785        | .638                                     | .731                    | .668                   |
| 3                         | $\frac{1}{3}$                     | .695   | .665                                  | .824                               | .752        | .598                                     | .699                    | .638                   |
| 3½                        | $\frac{2}{3}$                     | .665   | .635                                  | .802                               | .732        | .578                                     | .670                    | .596                   |
| 3⅔                        | $\frac{3}{4}$                     | .652   | .625                                  | .796                               | .716        | .568                                     | .661                    | .588                   |
| 3¾                        | $\frac{4}{5}$                     | .632   | .605                                  | .782                               | .704        | .548                                     | .642                    | .568                   |
| 3⅞                        | $\frac{1}{5}$                     | .608   | .580                                  | .775                               | .684        | .515                                     | .616                    | .538                   |
| 4                         | $\frac{1}{4}$                     | .587   | .550                                  | .750                               | .664        | .486                                     | .566                    | .518                   |
| 4½                        | $\frac{2}{3}$                     | .540   | .510                                  | .720                               | .624        | .441                                     | .555                    | .473                   |
| 5                         | $\frac{1}{5}$                     | .510   | .482                                  | .695                               | .600        | .406                                     | .522                    | .428                   |
| 5½                        | $\frac{2}{3}$                     | .478   | .455                                  | .674                               | .560        | .371                                     | .492                    | .406                   |
| 6                         | $\frac{1}{6}$                     | .454   | .420                                  | .650                               | .530        | .349                                     | .465                    | .378                   |
| 6½                        | $\frac{2}{3}$                     | .430   | .390                                  | .632                               | .515        | .326                                     | .441                    | .358                   |
| 7                         | $\frac{1}{7}$                     | .409   | .375                                  | .612                               | .500        | .303                                     | .421                    | .337                   |
| 8                         | $\frac{1}{8}$                     | .372   | .340                                  | .697                               | .468        | .276                                     | .385                    | .302                   |
| 10                        | $\frac{1}{10}$                    | .326   | .284                                  | .532                               | .412        | .225                                     | .330                    | .253                   |
| 20                        | $\frac{1}{20}$                    | .192   | .165                                  | .396                               | .272        | .103                                     | .200                    | .138                   |
| 50                        | $\frac{1}{50}$                    | .091   | .074                                  | .245                               | .193        | .050                                     | .098                    | .060                   |
| 100                       | $\frac{1}{100}$                   | .053   | .040                                  | .180                               | .134        | .025                                     | .056                    | .032                   |



III.—(Continued.)

MEAN PRESSURE RATIOS.

| r   | A     | B     | C     | r   | A    | B    | C    | r    | A    | B    | C    | r    | A    | B    | C    |
|-----|-------|-------|-------|-----|------|------|------|------|------|------|------|------|------|------|------|
| 1.0 | 1.000 | 1.000 | 1.000 | 5.3 | .478 | .503 | .488 | 9.6  | .312 | .340 | .324 | 17.8 | .194 | .218 | .204 |
| 1.1 | 0.996 | 0.996 | 0.996 | 5.4 | .472 | .497 | .482 | 9.7  | .310 | .338 | .322 | 18.0 | .192 | .216 | .202 |
| 1.2 | 0.983 | 0.983 | 0.983 | 5.5 | .467 | .492 | .477 | 9.8  | .307 | .335 | .319 | 18.2 | .190 | .215 | .200 |
| 1.3 | .966  | .968  | .967  | 5.6 | .461 | .486 | .471 | 9.9  | .305 | .333 | .317 | 18.4 | .189 | .214 | .199 |
| 1.4 | .947  | .952  | .950  | 5.7 | .456 | .481 | .466 | 10.0 | .303 | .330 | .314 | 18.6 | .187 | .212 | .197 |
| 1.5 | .928  | .934  | .931  | 5.8 | .450 | .475 | .460 | 10.2 | .299 | .325 | .310 | 18.8 | .185 | .210 | .195 |
| 1.6 | .910  | .919  | .914  | 5.9 | .445 | .470 | .455 | 10.4 | .295 | .321 | .306 | 19.0 | .183 | .208 | .193 |
| 1.7 | .890  | .900  | .895  | 6.0 | .440 | .465 | .450 | 10.6 | .291 | .317 | .302 | 19.2 | .182 | .207 | .192 |
| 1.8 | .870  | .880  | .875  | 6.1 | .434 | .460 | .445 | 10.8 | .287 | .313 | .298 | 19.4 | .180 | .205 | .190 |
| 1.9 | .850  | .862  | .856  | 6.2 | .429 | .455 | .440 | 11.0 | .283 | .309 | .294 | 19.6 | .179 | .204 | .189 |
| 2.0 | .833  | .846  | .840  | 6.3 | .424 | .450 | .435 | 11.2 | .279 | .305 | .290 | 19.8 | .178 | .202 | .187 |
| 2.1 | .817  | .830  | .824  | 6.4 | .419 | .445 | .430 | 11.4 | .275 | .301 | .286 | 20.0 | .177 | .200 | .186 |
| 2.2 | .798  | .812  | .805  | 6.5 | .414 | .441 | .426 | 11.6 | .272 | .298 | .283 | 20.2 | .175 | .198 | .184 |
| 2.3 | .780  | .795  | .787  | 6.6 | .409 | .436 | .421 | 11.8 | .268 | .294 | .279 | 20.4 | .174 | .196 | .183 |
| 2.4 | .763  | .780  | .771  | 6.7 | .405 | .432 | .417 | 12.0 | .264 | .290 | .275 | 20.6 | .173 | .194 | .182 |
| 2.5 | .748  | .766  | .756  | 6.8 | .401 | .428 | .413 | 12.2 | .261 | .287 | .272 | 20.8 | .171 | .193 | .180 |
| 2.6 | .732  | .750  | .740  | 6.9 | .396 | .424 | .408 | 12.4 | .257 | .283 | .268 | 21.0 | .169 | .192 | .178 |
| 2.7 | .718  | .736  | .726  | 7.0 | .393 | .421 | .405 | 12.6 | .254 | .280 | .265 | 21.2 | .168 | .191 | .177 |
| 2.8 | .705  | .723  | .713  | 7.1 | .389 | .417 | .401 | 12.8 | .251 | .277 | .262 | 21.4 | .167 | .190 | .176 |
| 2.9 | .692  | .710  | .700  | 7.2 | .385 | .413 | .397 | 13.0 | .248 | .274 | .259 | 21.6 | .165 | .188 | .174 |
| 3.0 | .680  | .699  | .688  | 7.3 | .381 | .410 | .393 | 13.2 | .245 | .271 | .256 | 21.8 | .164 | .187 | .173 |
| 3.1 | .668  | .687  | .676  | 7.4 | .377 | .406 | .390 | 13.4 | .242 | .268 | .253 | 22.0 | .163 | .186 | .172 |
| 3.2 | .656  | .675  | .664  | 7.5 | .373 | .402 | .386 | 13.6 | .239 | .265 | .250 | 22.2 | .162 | .185 | .171 |
| 3.3 | .645  | .664  | .653  | 7.6 | .370 | .399 | .383 | 13.8 | .236 | .262 | .247 | 22.4 | .161 | .184 | .170 |
| 3.4 | .634  | .653  | .642  | 7.7 | .367 | .396 | .380 | 14.0 | .234 | .260 | .245 | 22.6 | .160 | .183 | .169 |
| 3.5 | .622  | .642  | .631  | 7.8 | .363 | .392 | .376 | 14.2 | .231 | .257 | .242 | 22.8 | .159 | .182 | .168 |
| 3.6 | .612  | .632  | .621  | 7.9 | .360 | .389 | .373 | 14.4 | .228 | .254 | .239 | 23.0 | .158 | .180 | .167 |
| 3.7 | .602  | .622  | .611  | 8.0 | .356 | .385 | .370 | 14.6 | .225 | .251 | .236 | 23.2 | .156 | .179 | .165 |
| 3.8 | .593  | .613  | .602  | 8.1 | .353 | .382 | .367 | 14.8 | .223 | .249 | .234 | 23.4 | .155 | .178 | .164 |
| 3.9 | .584  | .604  | .593  | 8.2 | .350 | .379 | .364 | 15.0 | .221 | .247 | .232 | 23.6 | .154 | .177 | .163 |
| 4.0 | .572  | .596  | .583  | 8.3 | .347 | .376 | .361 | 15.2 | .219 | .245 | .230 | 23.8 | .153 | .176 | .162 |
| 4.1 | .565  | .587  | .575  | 8.4 | .344 | .373 | .358 | 15.4 | .217 | .242 | .227 | 24.0 | .151 | .174 | .160 |
| 4.2 | .556  | .578  | .566  | 8.5 | .341 | .371 | .355 | 15.6 | .215 | .240 | .225 | 24.2 | .150 | .173 | .159 |
| 4.3 | .548  | .570  | .558  | 8.6 | .338 | .368 | .352 | 15.8 | .213 | .238 | .223 | 24.4 | .149 | .172 | .158 |
| 4.4 | .540  | .563  | .550  | 8.7 | .335 | .364 | .349 | 16.0 | .211 | .236 | .221 | 24.6 | .148 | .171 | .157 |
| 4.5 | .532  | .555  | .542  | 8.8 | .332 | .361 | .346 | 16.2 | .209 | .234 | .219 | 24.8 | .147 | .170 | .156 |
| 4.6 | .525  | .548  | .535  | 8.9 | .330 | .358 | .34  | 16.4 | .207 | .232 | .217 | 25.0 | .146 | .169 | .155 |
| 4.7 | .518  | .542  | .528  | 9.0 | .327 | .355 | .340 | 16.6 | .205 | .230 | .215 |      |      |      |      |
| 4.8 | .511  | .535  | .521  | 9.1 | .324 | .353 | .337 | 16.8 | .203 | .228 | .213 |      |      |      |      |
| 4.9 | .504  | .528  | .514  | 9.2 | .322 | .351 | .335 | 17.0 | .201 | .226 | .211 |      |      |      |      |
| 5.0 | .496  | .522  | .506  | 9.3 | .320 | .348 | .332 | 17.2 | .199 | .224 | .209 |      |      |      |      |
| 5.1 | .490  | .515  | .500  | 9.4 | .317 | .345 | .329 | 17.4 | .197 | .222 | .207 |      |      |      |      |
| 5.2 | .484  | .509  | .494  | 9.5 | .315 | .343 | .327 | 17.6 | .195 | .220 | .205 |      |      |      |      |

Column r, the ratio of expansion =  $\frac{v_2}{v_1}$

- " A, ratio of mean to initial pressure,  $\frac{p_m}{p_1} = \frac{10 - 9r^{-\frac{1}{3}}}{r}$  { For dry steam, expanded without gain or loss of heat, in a non-conducting cylinder.
- " B, " " " "  $\frac{p_m}{p_1} = \frac{1 + \text{hyp. log. } r}{r}$  { For damp steam, expanded receiving heat.
- " C, " " " "  $\frac{p_m}{p_1} = \frac{17 - 16r^{-\frac{1}{8}}}{r}$  { For dry steam, expanded receiving heat sufficient to prevent liquefaction.

RULE.—To find the mean pressure exerted throughout the stroke, multiply the initial pressure by the number opposite the ratio of expansion, in the column corresponding with the conditions of expansion. (From Northcott.)

IV.

TERMINAL PRESSURE RATIOS  $\frac{p_1}{p_2}$

| $r$ | A    | B   | C    | $r$ | A    | B   | C    | $r$  | A    | B    | C    | $r$  | A    | B    | C    |
|-----|------|-----|------|-----|------|-----|------|------|------|------|------|------|------|------|------|
| 1.0 | 0.00 | 0.0 | 0.00 | 4.7 | 5.58 | 4.7 | 5.18 | 8.3  | 10.5 | 8.3  | 9.47 | 13.8 | 18.5 | 13.8 | 16.2 |
| 1.1 | 1.11 | 1.1 | 1.11 | 4.8 | 5.70 | 4.8 | 5.29 | 8.4  | 10.6 | 8.4  | 9.59 | 14.0 | 18.8 | 14.0 | 16.5 |
| 1.2 | 1.22 | 1.2 | 1.21 | 4.9 | 5.84 | 4.9 | 5.41 | 8.5  | 10.7 | 8.5  | 9.64 | 14.2 | 19.1 | 14.2 | 16.8 |
| 1.3 | 1.34 | 1.3 | 1.32 | 5.0 | 5.98 | 5.0 | 5.52 | 8.6  | 10.9 | 8.6  | 9.76 | 14.4 | 19.4 | 14.4 | 17.0 |
| 1.4 | 1.45 | 1.4 | 1.43 | 5.1 | 6.11 | 5.1 | 5.64 | 8.7  | 11.0 | 8.7  | 9.88 | 14.6 | 19.7 | 14.6 | 17.2 |
| 1.5 | 1.57 | 1.5 | 1.54 | 5.2 | 6.24 | 5.2 | 5.76 | 8.8  | 11.2 | 8.8  | 10.0 | 14.8 | 20.0 | 14.8 | 17.5 |
| 1.6 | 1.69 | 1.6 | 1.65 | 5.3 | 6.38 | 5.3 | 5.88 | 8.9  | 11.3 | 8.9  | 10.2 | 15.0 | 20.3 | 15.0 | 17.8 |
| 1.7 | 1.80 | 1.7 | 1.75 | 5.4 | 6.51 | 5.4 | 6.00 | 9.0  | 11.5 | 9.0  | 10.3 | 15.2 | 20.6 | 15.2 | 18.0 |
| 1.8 | 1.92 | 1.8 | 1.87 | 5.5 | 6.64 | 5.5 | 6.12 | 9.1  | 11.6 | 9.1  | 10.4 | 15.4 | 20.9 | 15.4 | 18.2 |
| 1.9 | 2.04 | 1.9 | 1.98 | 5.6 | 6.78 | 5.6 | 6.23 | 9.2  | 11.8 | 9.2  | 10.6 | 15.6 | 21.2 | 15.6 | 18.5 |
| 2.0 | 2.16 | 2.0 | 2.08 | 5.7 | 6.91 | 5.7 | 6.35 | 9.3  | 11.9 | 9.3  | 10.7 | 15.8 | 21.5 | 15.8 | 18.7 |
| 2.1 | 2.28 | 2.1 | 2.20 | 5.8 | 7.05 | 5.8 | 6.47 | 9.4  | 12.0 | 9.4  | 10.8 | 16.0 | 21.8 | 16.0 | 19.0 |
| 2.2 | 2.40 | 2.2 | 2.31 | 5.9 | 7.18 | 5.9 | 6.59 | 9.5  | 12.2 | 9.5  | 10.9 | 16.2 | 22.1 | 16.2 | 19.3 |
| 2.3 | 2.52 | 2.3 | 2.42 | 6.0 | 7.32 | 6.0 | 6.71 | 9.6  | 12.3 | 9.6  | 11.0 | 16.4 | 22.4 | 16.4 | 19.5 |
| 2.4 | 2.64 | 2.4 | 2.53 | 6.1 | 7.45 | 6.1 | 6.83 | 9.7  | 12.5 | 9.7  | 11.1 | 16.6 | 22.7 | 16.6 | 19.8 |
| 2.5 | 2.76 | 2.5 | 2.64 | 6.2 | 7.59 | 6.2 | 6.95 | 9.8  | 12.6 | 9.8  | 11.3 | 16.8 | 23.0 | 16.8 | 20.0 |
| 2.6 | 2.89 | 2.6 | 2.76 | 6.3 | 7.73 | 6.3 | 7.07 | 9.9  | 12.8 | 9.9  | 11.4 | 17.0 | 23.3 | 17.0 | 20.3 |
| 2.7 | 3.01 | 2.7 | 2.87 | 6.4 | 7.86 | 6.4 | 7.18 | 10.0 | 12.9 | 10.0 | 11.5 | 17.2 | 23.6 | 17.2 | 20.5 |
| 2.8 | 3.14 | 2.8 | 2.99 | 6.5 | 8.00 | 6.5 | 7.30 | 10.2 | 13.2 | 10.2 | 11.7 | 17.4 | 23.9 | 17.4 | 20.8 |
| 2.9 | 3.26 | 2.9 | 3.10 | 6.6 | 8.14 | 6.6 | 7.42 | 10.4 | 13.5 | 10.4 | 12.0 | 17.6 | 24.2 | 17.6 | 21.0 |
| 3.0 | 3.39 | 3.0 | 3.21 | 6.7 | 8.27 | 6.7 | 7.54 | 10.6 | 13.8 | 10.6 | 12.3 | 17.8 | 24.5 | 17.8 | 21.3 |
| 3.1 | 3.51 | 3.1 | 3.32 | 6.8 | 8.41 | 6.8 | 7.66 | 10.8 | 14.1 | 10.8 | 12.5 | 18.0 | 24.8 | 18.0 | 21.6 |
| 3.2 | 3.64 | 3.2 | 3.43 | 6.9 | 8.55 | 6.9 | 7.78 | 11.0 | 14.3 | 11.0 | 12.8 | 18.2 | 25.1 | 18.2 | 21.8 |
| 3.3 | 3.77 | 3.3 | 3.55 | 7.0 | 8.69 | 7.0 | 7.90 | 11.2 | 14.6 | 11.2 | 13.0 | 18.4 | 25.4 | 18.4 | 22.0 |
| 3.4 | 3.89 | 3.4 | 3.67 | 7.1 | 8.83 | 7.1 | 8.02 | 11.4 | 14.9 | 11.4 | 13.3 | 18.6 | 25.7 | 18.6 | 22.3 |
| 3.5 | 4.02 | 3.5 | 3.79 | 7.2 | 8.96 | 7.2 | 8.14 | 11.6 | 15.2 | 11.6 | 13.5 | 18.8 | 26.0 | 18.8 | 22.5 |
| 3.6 | 4.15 | 3.6 | 3.90 | 7.3 | 9.10 | 7.3 | 8.27 | 11.8 | 15.5 | 11.8 | 13.7 | 19.0 | 26.3 | 19.0 | 22.8 |
| 3.7 | 4.28 | 3.7 | 4.01 | 7.4 | 9.24 | 7.4 | 8.38 | 12.0 | 15.8 | 12.0 | 14.0 | 19.2 | 26.6 | 19.2 | 23.1 |
| 3.8 | 4.41 | 3.8 | 4.13 | 7.5 | 9.38 | 7.5 | 8.49 | 12.2 | 16.1 | 12.2 | 14.2 | 19.4 | 26.9 | 19.4 | 23.3 |
| 3.9 | 4.54 | 3.9 | 4.25 | 7.6 | 9.52 | 7.6 | 8.62 | 12.4 | 16.4 | 12.4 | 14.5 | 19.6 | 27.2 | 19.6 | 23.6 |
| 4.0 | 4.66 | 4.0 | 4.36 | 7.7 | 9.66 | 7.7 | 8.74 | 12.6 | 16.7 | 12.6 | 14.8 | 19.8 | 27.5 | 19.8 | 23.9 |
| 4.1 | 4.79 | 4.1 | 4.47 | 7.8 | 9.80 | 7.8 | 8.87 | 12.8 | 17.0 | 12.8 | 15.0 | 20.0 | 27.9 | 20.0 | 24.1 |
| 4.2 | 4.91 | 4.2 | 4.60 | 7.9 | 9.94 | 7.9 | 8.99 | 13.0 | 17.3 | 13.0 | 15.2 | 21.0 | 29.5 | 21.0 | 25.4 |
| 4.3 | 5.05 | 4.3 | 4.71 | 8.0 | 10.1 | 8.0 | 9.11 | 13.2 | 17.6 | 13.2 | 15.5 | 22.0 | 31.0 | 22.0 | 26.7 |
| 4.4 | 5.18 | 4.4 | 4.82 | 8.1 | 10.2 | 8.1 | 9.23 | 13.4 | 17.9 | 13.4 | 15.7 | 23.0 | 32.6 | 23.0 | 28.0 |
| 4.5 | 5.32 | 4.5 | 4.95 | 8.2 | 10.3 | 8.2 | 9.35 | 13.6 | 18.2 | 13.6 | 16.0 | 24.0 | 34.1 | 24.0 | 29.3 |
| 4.6 | 5.45 | 4.6 | 5.06 |     |      |     |      |      |      |      |      |      |      |      |      |

Column  $r$ , ratio of expansion =  $\frac{v_2}{v_1}$

" A, ratio of initial to final pressure,  $p_2 = \frac{p_1}{r^{1/\beta}}$  .. { For dry steam, expanded without gain or loss of heat in a non-conducting cylinder.

" B, " " " "  $p_2 = \frac{p_1}{r}$  .. { For damp steam, expanded receiving heat.

" C, " " " "  $p_2 = \frac{p_1}{r^{1/\beta}}$  .. { For dry steam, expanded receiving sufficient heat to prevent liquefaction.

**RULE.**—To find the final pressure obtaining with any ratio of expansion, divide the initial pressure by the number opposite the ratio of expansion, in the column corresponding with the conditions of expansion.







## VI.

## COMPARISON OF THERMOMETERS.

| Celsius. | Réaumur. | Fahren-<br>heit. | Celsius. | Réaumur. | Fahren-<br>heit. | Celsius. | Réaumur. | Fahren-<br>heit. |
|----------|----------|------------------|----------|----------|------------------|----------|----------|------------------|
| -20      | -16      | -4               | 25       | 20.0     | 77.0             | 70       | 56.0     | 158.0            |
| -19      | -15.2    | -2.2             | 26       | 20.8     | 78.8             | 71       | 56.8     | 159.8            |
| -18      | -14.4    | -0.4             | 27       | 21.6     | 80.6             | 72       | 57.6     | 161.6            |
| -17      | -13.6    | 1.4              | 28       | 22.4     | 82.4             | 73       | 58.4     | 163.4            |
| -16      | -12.8    | 3.2              | 29       | 23.2     | 84.2             | 74       | 59.2     | 165.2            |
| -15      | -12.0    | 5.0              | 30       | 24.0     | 86.0             | 75       | 60.0     | 167.0            |
| -14      | -11.2    | 6.8              | 31       | 24.8     | 87.8             | 76       | 60.8     | 168.8            |
| -13      | -10.4    | 8.6              | 32       | 25.6     | 89.6             | 77       | 61.6     | 170.6            |
| -12      | -9.6     | 10.4             | 33       | 26.4     | 91.4             | 78       | 62.4     | 172.4            |
| -11      | -8.8     | 12.2             | 34       | 27.2     | 93.2             | 79       | 63.2     | 174.2            |
| -10      | -8.0     | 14.0             | 35       | 28.0     | 95.0             | 80       | 64.0     | 176.0            |
| -9       | -7.2     | 15.8             | 36       | 28.8     | 96.8             | 81       | 64.8     | 177.8            |
| -8       | -6.4     | 17.6             | 37       | 29.6     | 98.6             | 82       | 65.6     | 179.6            |
| -7       | -5.6     | 19.4             | 38       | 30.4     | 100.4            | 83       | 66.4     | 181.4            |
| -6       | -4.8     | 21.2             | 39       | 31.2     | 102.2            | 84       | 67.2     | 183.2            |
| -5       | -4.0     | 23.0             | 40       | 32.0     | 104.0            | 85       | 68.0     | 185.0            |
| -4       | -3.2     | 24.8             | 41       | 32.8     | 105.8            | 86       | 68.8     | 186.8            |
| -3       | -2.4     | 26.6             | 42       | 33.6     | 107.6            | 87       | 69.6     | 188.6            |
| -2       | -1.6     | 28.4             | 43       | 34.4     | 109.4            | 88       | 70.4     | 190.4            |
| -1       | -0.8     | 30.2             | 44       | 35.2     | 111.2            | 89       | 71.2     | 192.2            |
| 0        | 0        | 32.0             | 45       | 36.0     | 113.0            | 90       | 72.0     | 194.0            |
| 1        | 0.8      | 33.8             | 46       | 36.8     | 114.8            | 91       | 72.8     | 195.8            |
| 2        | 1.6      | 35.6             | 47       | 37.6     | 116.6            | 92       | 73.6     | 197.6            |
| 3        | 2.4      | 37.4             | 48       | 38.4     | 118.4            | 93       | 74.4     | 199.4            |
| 4        | 3.2      | 39.2             | 49       | 39.2     | 120.2            | 94       | 75.2     | 201.2            |
| 5        | 4.0      | 41.0             | 50       | 40.0     | 122.0            | 95       | 76.0     | 203.0            |
| 6        | 4.8      | 42.8             | 51       | 40.8     | 123.8            | 96       | 76.8     | 204.8            |
| 7        | 5.6      | 44.6             | 52       | 41.6     | 125.6            | 97       | 77.6     | 206.6            |
| 8        | 6.4      | 46.4             | 53       | 42.4     | 127.4            | 98       | 78.4     | 208.4            |
| 9        | 7.2      | 48.2             | 54       | 43.2     | 129.2            | 99       | 79.2     | 210.2            |
| 10       | 8.0      | 50.0             | 55       | 44.0     | 131.0            | 100      | 80.0     | 212.0            |
| 11       | 8.8      | 51.8             | 56       | 44.8     | 132.8            | 101      | 80.8     | 213.8            |
| 12       | 9.6      | 53.6             | 57       | 45.6     | 134.6            | 102      | 81.6     | 215.6            |
| 13       | 10.4     | 55.4             | 58       | 46.4     | 136.4            | 103      | 82.4     | 217.4            |
| 14       | 11.2     | 57.2             | 59       | 47.2     | 138.2            | 104      | 83.2     | 219.2            |
| 15       | 12.0     | 59.0             | 60       | 48.0     | 140.0            | 105      | 84.0     | 221.0            |
| 16       | 12.8     | 60.8             | 61       | 48.8     | 141.8            | 106      | 84.8     | 222.8            |
| 17       | 13.6     | 62.6             | 62       | 49.6     | 143.6            | 107      | 85.6     | 224.6            |
| 18       | 14.4     | 64.4             | 63       | 50.4     | 145.4            | 108      | 86.4     | 226.4            |
| 19       | 15.2     | 66.2             | 64       | 51.2     | 147.2            | 109      | 87.2     | 228.2            |
| 20       | 16.0     | 68.0             | 65       | 52.0     | 149.0            | 110      | 88.0     | 230.0            |
| 21       | 16.8     | 69.8             | 66       | 52.8     | 150.8            | 111      | 88.8     | 231.8            |
| 22       | 17.6     | 71.6             | 67       | 53.6     | 152.6            | 112      | 89.6     | 233.6            |
| 23       | 18.4     | 73.4             | 68       | 54.4     | 154.4            | 113      | 90.4     | 235.4            |
| 24       | 19.2     | 75.2             | 69       | 55.2     | 156.2            | 114      | 91.2     | 237.2            |

COMPARISON OF THERMOMETERS—*Continued.*

| Celsius. | Réaumur. | Fahren-<br>heit. | Celsius. | Réaumur. | Fahren-<br>heit. | Celsius. | Réaumur. | Fahren-<br>heit. |
|----------|----------|------------------|----------|----------|------------------|----------|----------|------------------|
| 115      | 92.0     | 239.0            | 127      | 101.6    | 260.6            | 139      | 111.2    | 282.2            |
| 116      | 92.8     | 240.8            | 128      | 102.4    | 262.4            | 140      | 112.0    | 284.0            |
| 117      | 93.6     | 242.6            | 129      | 103.2    | 264.2            | 141      | 112.8    | 285.8            |
| 118      | 94.4     | 244.4            | 130      | 104.0    | 266.0            | 142      | 113.6    | 287.6            |
| 119      | 95.2     | 246.2            | 131      | 104.8    | 267.8            | 143      | 114.4    | 289.4            |
| 120      | 96.0     | 248.0            | 132      | 105.6    | 269.6            | 144      | 115.2    | 291.2            |
| 121      | 96.8     | 249.8            | 133      | 106.4    | 271.4            | 145      | 116.0    | 293.0            |
| 122      | 97.6     | 251.6            | 134      | 107.2    | 273.2            | 146      | 116.8    | 294.8            |
| 123      | 98.4     | 253.4            | 135      | 108.0    | 275.0            | 147      | 117.6    | 296.6            |
| 124      | 99.2     | 255.2            | 136      | 108.8    | 276.8            | 148      | 118.4    | 298.4            |
| 125      | 100.0    | 257.0            | 137      | 109.6    | 278.6            | 149      | 119.2    | 300.2            |
| 126      | 100.8    | 258.8            | 138      | 110.4    | 280.4            | 150      | 120.0    | 302.0            |

## VII.

## DENSITIES AND VOLUMES OF WATER.

KOPP; CORRECTED BY PORTER.

| Temperature. |     | Volume, Kopp. | Corrected Volume. | Differences. |    |
|--------------|-----|---------------|-------------------|--------------|----|
| F.           | C.  |               |                   |              |    |
| 39.2         | 4   | 1.00000       | 1.00000           |              |    |
| 41.0         | 5   | 1.00001       | 1.00001           |              |    |
| 51.8         | 10  | 1.00025       | 1.00025           | 24           | 34 |
| 59.0         | 15  | 1.00082       | 1.00083           | 58           | 27 |
| 68.0         | 20  | 1.00169       | 1.00171           | 88           | 30 |
| 77.0         | 25  | 1.00284       | 1.00286           | 115          | 24 |
| 86.0         | 30  | 1.00423       | 1.00425           | 139          | 22 |
| 95.0         | 35  | 1.00583       | 1.00586           | 161          | 20 |
| 104.0        | 40  | 1.00768       | 1.00767           | 181          | 19 |
| 113.0        | 45  | 1.00967       | 1.00967           | 200          | 19 |
| 122.0        | 50  | 1.01190       | 1.01186           | 219          | 18 |
| 131.0        | 55  | 1.01423       | 1.01423           | 237          | 18 |
| 140.0        | 60  | 1.01672       | 1.01678           | 255          | 18 |
| 149.0        | 65  | 1.01943       | 1.01951           | 273          | 17 |
| 150.0        | 70  | 1.02238       | 1.02241           | 290          | 17 |
| 167.0        | 75  | 1.02554       | 1.02548           | 307          | 17 |
| 176.0        | 80  | 1.02871       | 1.02872           | 324          | 17 |
| 185.0        | 85  | 1.03202       | 1.03213           | 341          | 16 |
| 194.0        | 90  | 1.03553       | 1.03570           | 357          | 16 |
| 203.0        | 95  | 1.03921       | 1.03943           | 373          | 16 |
| 212.0        | 100 | 1.04312       | 1.04332           | 389          | 16 |

## WEIGHTS AND VOLUMES.

| Temperature. | Ratio of volume to that of equal weight at maximum density. | Weight of a cubic foot. | Temperature. | Ratio of volume to that of equal weight at maximum density. | Weight of a cubic foot. | Temperature. | Ratio of volume to that of equal weight at maximum density. | Weight of a cubic foot. |
|--------------|---|-------------------------|--------------|---|-------------------------|--------------|---|-------------------------|
| Fahr.        |   | Lbs.                    | Fahr.        |   | Lbs.                    | Fahr.        |   | Lbs.                    |
| 32.0         | 1.000129  | 62.417                  | 210.0        | 1.04226   | 59.894                  | 390.0        | 1.15538   | 54.030                  |
| 39.1         | 1.000000  | 62.425                  | 212.         | 1.04312   | 59.707                  | 400.         | 1.16366   | 53.635                  |
| 40.          | 1.000004  | 62.423                  | 220.         | 1.04668   | 59.641                  | 410.         | 1.17218   | 53.255                  |
| 50.          | 1.000253  | 62.400                  | 230.         | 1.05142   | 59.372                  | 420.         | 1.18090   | 52.862                  |
| 60.          | 1.000929  | 62.367                  | 240.         | 1.05633   | 59.096                  | 430.         | 1.18982   | 52.466                  |
| 70.          | 1.001981  | 62.302                  | 250.         | 1.06144   | 58.812                  | 440.         | 1.19898   | 52.065                  |
| 80.          | 1.00332   | 62.218                  | 260.         | 1.06679   | 58.517                  | 450.         | 1.20833   | 51.662                  |
| 90.          | 1.00492   | 62.119                  | 270.         | 1.07233   | 58.214                  | 460.         | 1.21790   | 51.256                  |
| 100.         | 1.00686   | 62.000                  | 280.         | 1.07809   | 57.903                  | 470.         | 1.22766   | 50.848                  |
| 110.         | 1.00902   | 61.867                  | 290.         | 1.08405   | 57.585                  | 480.         | 1.23766   | 50.438                  |
| 120.         | 1.01143   | 61.720                  | 300.         | 1.09023   | 57.259                  | 490.         | 1.24785   | 50.026                  |
| 130.         | 1.01411   | 61.556                  | 310.         | 1.09661   | 56.925                  | 500.         | 1.25828   | 49.611                  |
| 140.         | 1.01690   | 61.388                  | 320.         | 1.10323   | 56.584                  | 510.         | 1.26892   | 49.195                  |
| 150.         | 1.01995   | 61.204                  | 330.         | 1.11005   | 56.236                  | 520.         | 1.27975   | 48.778                  |
| 160.         | 1.02324   | 61.007                  | 340.         | 1.11706   | 55.883                  | 530.         | 1.29080   | 48.360                  |
| 170.         | 1.02671   | 60.801                  | 350.         | 1.12431   | 55.523                  | 540.         | 1.30204   | 47.941                  |
| 180.         | 1.03033   | 60.587                  | 360.         | 1.13175   | 55.158                  | 550.         | 1.31354   | 47.521                  |
| 190.         | 1.03411   | 60.366                  | 370.         | 1.13942   | 54.787                  |              |   |                         |
| 200.         | 1.03807   | 60.136                  | 380.         | 1.14729   | 54.411                  |              |   |                         |



VIII.

TEMPERATURES AND PRESSURES, SATURATED STEAM.  
IN METRIC MEASURES AND FROM REGNAULT.

| Temperature. | STEAM-PRESSURE. |                | Temperature. | STEAM-PRESSURE. |                |
|--------------|-----------------|----------------|--------------|-----------------|----------------|
|              | In Centimetres. | In Atmospheres |              | In Centimetres. | In Atmospheres |
| - 32° C.     | 0.0320          | 0.0004         | + 14° C.     | 1.1908          | 0.016          |
| 31           | 0.0352          | 0.0005         | 15           | 1.2699          | 0.017          |
| 30           | 0.0386          | 0.0005         | 16           | 1.3536          | 0.018          |
| 29           | 0.0424          | 0.0006         | 17           | 1.4421          | 0.019          |
| 28           | 0.0464          | 0.0006         | 18           | 1.5357          | 0.020          |
| 27           | 0.0508          | 0.0007         | 19           | 1.6346          | 0.022          |
| 26           | 0.0555          | 0.0007         | 20           | 1.7391          | 0.023          |
| 25           | 0.0605          | 0.0008         | 21           | 1.8495          | 0.024          |
| 24           | 0.0660          | 0.0009         | 22           | 1.9659          | 0.026          |
| 23           | 0.0719          | 0.0009         | 23           | 2.0888          | 0.028          |
| 22           | 0.0783          | 0.0010         | 24           | 2.2184          | 0.029          |
| 21           | 0.0853          | 0.0011         | 25           | 2.3550          | 0.031          |
| 20           | 0.0927          | 0.0012         | 26           | 2.4988          | 0.033          |
| 19           | 0.1008          | 0.0013         | 27           | 2.5505          | 0.034          |
| 18           | 0.1095          | 0.0014         | 28           | 2.8101          | 0.037          |
| 17           | 0.1189          | 0.0015         | 29           | 2.9782          | 0.039          |
| 16           | 0.1290          | 0.0017         | 30           | 3.1548          | 0.042          |
| 15           | 0.1400          | 0.0018         | 31           | 3.3406          | 0.044          |
| 14           | 0.1518          | 0.0020         | 32           | 3.5359          | 0.047          |
| 13           | 0.1646          | 0.0022         | 33           | 3.7411          | 0.049          |
| 12           | 0.1783          | 0.0024         | 34           | 3.9565          | 0.052          |
| 11           | 0.1933          | 0.0025         | 35           | 4.1827          | 0.055          |
| 10           | 0.2093          | 0.0027         | 36           | 4.4201          | 0.058          |
| 9            | 0.2267          | 0.0030         | 37           | 4.6691          | 0.061          |
| 8            | 0.2455          | 0.0032         | 38           | 4.9302          | 0.065          |
| 7            | 0.2658          | 0.0035         | 39           | 5.2039          | 0.068          |
| 6            | 0.2876          | 0.0038         | 40           | 5.4906          | 0.072          |
| 5            | 0.3113          | 0.0041         | 41           | 5.7910          | 0.076          |
| 4            | 0.3368          | 0.0044         | 42           | 6.1055          | 0.080          |
| 3            | 0.3644          | 0.0048         | 43           | 6.4346          | 0.085          |
| 2            | 0.3941          | 0.0052         | 44           | 6.7790          | 0.089          |
| 1            | 0.4263          | 0.0056         | 45           | 7.1391          | 0.094          |
| 0            | 0.4600          | 0.0061         | 46           | 7.5158          | 0.099          |
| + 1          | 0.4940          | 0.0065         | 47           | 7.9093          | 0.104          |
| 2            | 0.5302          | 0.0070         | 48           | 8.3204          | 0.109          |
| 3            | 0.5687          | 0.0073         | 49           | 8.7499          | 0.115          |
| 4            | 0.6097          | 0.0080         | 50           | 9.1982          | 0.121          |
| 5            | 0.6534          | 0.0086         | 51           | 9.6661          | 0.127          |
| 6            | 0.6998          | 0.0092         | 52           | 10.1543         | 0.134          |
| 7            | 0.7492          | 0.0109         | 53           | 10.6636         | 0.140          |
| 8            | 0.8017          | 0.0107         | 54           | 11.1945         | 0.147          |
| 9            | 0.8574          | 0.0111         | 55           | 11.7478         | 0.155          |
| 10           | 0.9165          | 0.012          | 56           | 12.3244         | 0.163          |
| 11           | 0.9792          | 0.013          | 57           | 12.9251         | 0.170          |
| 12           | 1.0457          | 0.014          | 58           | 13.5505         | 0.178          |
| 13           | 1.1162          | 0.015          | 59           | 14.2015         | 0.187          |

TEMPERATURES AND PRESSURES, SATURATED STEAM—*Continued.*

| Temperature. | STEAM-PRESSURE. |                | Temperature. | STEAM-PRESSURE. |                |
|--------------|-----------------|----------------|--------------|-----------------|----------------|
|              | In Centimetres. | In Atmospheres |              | In Centimetres. | In Atmospheres |
| + 60° C.     | 14.8791         | 0.196          | + 110° C.    | 107.537         | 1.415          |
| 61           | 15.5839         | 0.205          | 111          | 111.209         | 1.463          |
| 62           | 16.3170         | 0.215          | 112          | 114.983         | 1.513          |
| 63           | 17.0791         | 0.225          | 113          | 118.861         | 1.564          |
| 64           | 17.8714         | 0.235          | 114          | 122.847         | 1.616          |
| 65           | 18.6945         | 0.246          | 115          | 126.941         | 1.670          |
| 66           | 19.5496         | 0.257          | 116          | 131.147         | 1.726          |
| 67           | 20.4376         | 0.267          | 117          | 135.466         | 1.782          |
| 68           | 21.3596         | 0.281          | 118          | 139.902         | 1.841          |
| 69           | 22.3165         | 0.294          | 119          | 144.455         | 1.901          |
| 70           | 23.3093         | 0.306          | 120          | 149.128         | 1.962          |
| 71           | 24.3393         | 0.320          | 121          | 153.925         | 2.025          |
| 72           | 25.4073         | 0.334          | 122          | 158.847         | 2.091          |
| 73           | 26.5147         | 0.349          | 123          | 163.896         | 2.157          |
| 74           | 27.6624         | 0.364          | 124          | 169.076         | 2.225          |
| 75           | 28.8517         | 0.380          | 125          | 174.388         | 2.295          |
| 76           | 30.0838         | 0.396          | 126          | 179.835         | 2.366          |
| 77           | 31.3600         | 0.414          | 127          | 185.420         | 2.430          |
| 78           | 32.6811         | 0.430          | 128          | 191.147         | 2.515          |
| 79           | 34.0488         | 0.448          | 129          | 197.015         | 2.592          |
| 80           | 35.4643         | 0.466          | 130          | 203.028         | 2.671          |
| 81           | 36.9287         | 0.486          | 131          | 209.194         | 2.753          |
| 82           | 38.4435         | 0.506          | 132          | 215.503         | 2.836          |
| 83           | 40.0101         | 0.526          | 133          | 221.969         | 2.921          |
| 84           | 41.6298         | 0.548          | 134          | 228.592         | 3.008          |
| 85           | 43.3041         | 0.570          | 135          | 235.373         | 3.097          |
| 86           | 45.0344         | 0.593          | 136          | 242.316         | 3.188          |
| 87           | 46.8221         | 0.616          | 137          | 249.423         | 3.282          |
| 88           | 48.6687         | 0.640          | 138          | 256.700         | 3.378          |
| 89           | 50.5759         | 0.665          | 139          | 264.144         | 3.476          |
| 90           | 52.5450         | 0.691          | 140          | 271.763         | 3.576          |
| 91           | 54.5778         | 0.719          | 141          | 279.557         | 3.678          |
| 92           | 56.6757         | 0.746          | 142          | 287.530         | 3.783          |
| 93           | 58.8406         | 0.774          | 143          | 295.686         | 3.890          |
| 94           | 61.0740         | 0.804          | 144          | 304.026         | 4.000          |
| 95           | 63.3778         | 0.834          | 145          | 312.555         | 4.113          |
| 96           | 65.7535         | 0.865          | 146          | 321.274         | 4.227          |
| 97           | 68.2029         | 0.897          | 147          | 330.187         | 4.344          |
| 98           | 70.7280         | 0.931          | 148          | 339.298         | 4.464          |
| 99           | 73.3305         | 0.965          | 149          | 348.609         | 4.587          |
| 100          | 76.000          | 1.000          | 150          | 358.123         | 4.712          |
| 101          | 76.7590         | 1.036          | 151          | 367.843         | 4.840          |
| 102          | 81.6010         | 1.074          | 152          | 377.774         | 4.971          |
| 103          | 84.5280         | 1.112          | 153          | 387.918         | 5.104          |
| 104          | 87.5410         | 1.152          | 154          | 398.277         | 5.240          |
| 105          | 90.6410         | 1.193          | 155          | 408.856         | 5.380          |
| 106          | 93.8310         | 1.235          | 156          | 419.659         | 5.522          |
| 107          | 97.1140         | 1.278          | 157          | 430.688         | 5.667          |
| 108          | 100.4910        | 1.322          | 158          | 441.945         | 5.815          |
| 109          | 103.965         | 1.368          | 159          | 453.436         | 5.966          |

TEMPERATURES AND PRESSURES, SATURATED STEAM—*Continued.*

| Temperature. | STEAM-PRESSURE. |                | Temperature. | STEAM-PRESSURE. |                |
|--------------|-----------------|----------------|--------------|-----------------|----------------|
|              | In Centimetres. | In Atmospheres |              | In Centimetres. | In Atmospheres |
| +160° C.     | 465.162         | 6.120          | +196° C.     | 1074.595        | 14.139         |
| 161          | 477.128         | 6.278          | 197          | 1097.500        | 14.441         |
| 162          | 489.336         | 6.439          | 198          | 1120.982        | 14.749         |
| 163          | 501.791         | 6.603          | 199          | 1144.746        | 15.062         |
| 164          | 514.497         | 6.770          | 200          | 1168.896        | 15.380         |
| 165          | 527.454         | 6.940          | 201          | 1193.437        | 15.703         |
| 166          | 540.669         | 7.114          | 202          | 1218.369        | 16.031         |
| 167          | 554.143         | 7.291          | 203          | 1243.700        | 16.364         |
| 168          | 567.882         | 7.472          | 204          | 1269.430        | 16.703         |
| 169          | 581.890         | 7.656          | 205          | 1295.566        | 17.047         |
| 170          | 596.166         | 7.844          | 206          | 1322.112        | 17.396         |
| 171          | 610.719         | 8.036          | 207          | 1349.075        | 17.751         |
| 172          | 625.548         | 8.231          | 208          | 1376.453        | 18.111         |
| 173          | 640.660         | 8.430          | 209          | 1404.252        | 18.477         |
| 174          | 656.055         | 8.632          | 210          | 1432.480        | 18.848         |
| 175          | 671.743         | 8.839          | 211          | 1461.132        | 19.226         |
| 176          | 687.722         | 9.049          | 212          | 1490.222        | 19.608         |
| 177          | 703.997         | 9.263          | 213          | 1519.748        | 19.997         |
| 178          | 720.572         | 9.481          | 214          | 1549.717        | 20.391         |
| 179          | 737.452         | 9.703          | 215          | 1580.133        | 20.791         |
| 180          | 754.639         | 9.929          | 216          | 1610.994        | 21.197         |
| 181          | 772.137         | 10.150         | 217          | 1642.315        | 21.600         |
| 182          | 789.952         | 10.394         | 218          | 1674.090        | 22.027         |
| 183          | 808.084         | 10.633         | 219          | 1706.329        | 22.452         |
| 184          | 826.540         | 10.876         | 220          | 1739.036        | 22.882         |
| 185          | 845.323         | 11.123         | 221          | 1772.213        | 23.319         |
| 186          | 864.435         | 11.374         | 222          | 1805.864        | 23.761         |
| 187          | 883.882         | 11.630         | 223          | 1839.994        | 24.210         |
| 188          | 903.668         | 11.885         | 224          | 1874.607        | 24.666         |
| 189          | 923.795         | 12.155         | 225          | 1909.704        | 25.128         |
| 190          | 944.270         | 12.425         | 226          | 1945.292        | 25.596         |
| 191          | 965.093         | 12.699         | 227          | 1981.376        | 26.071         |
| 192          | 986.271         | 12.977         | 228          | 2017.961        | 26.552         |
| 193          | 1007.804        | 13.261         | 229          | 2055.048        | 27.040         |
| 194          | 1029.701        | 13.549         | 230          | 2092.640        | 27.535         |
| 195          | 1051.963        | 13.842         |              |                 |                |

**IX.**  
**METRIC STEAM AND WORK TABLE.**

| Absolute pressures in Atmosphere. | Specific volumes $v_0$ in Cu. meters. | Product $p_0 v_0$ . | $W = \frac{26127.34}{1000 p_0 v_0}$ | W . $p_0$ . |
|-----------------------------------|---------------------------------------|---------------------|-------------------------------------|-------------|
| 0.1                               | 14.504                                | 1.450               | 18.010                              | 1.801       |
| 0.2                               | 7.525                                 | 1.505               | 17.418                              | 3.483       |
| 0.3                               | 5.128                                 | 1.540               | 16.960                              | 5.088       |
| 0.4                               | 3.908                                 | 1.560               | 16.750                              | 6.700       |
| 0.5                               | 3.165                                 | 1.580               | 16.530                              | 8.265       |
| 0.6                               | 2.665                                 | 1.600               | 16.339                              | 9.803       |
| 0.7                               | 2.304                                 | 1.610               | 16.230                              | 11.361      |
| 0.8                               | 2.031                                 | 1.620               | 16.120                              | 12.896      |
| 0.9                               | 1.818                                 | 1.630               | 16.020                              | 14.418      |
| 1.0                               | 1.646                                 | 1.646               | 15.870                              | 15.870      |
| 1.1                               | 1.505                                 | 1.655               | 15.780                              | 17.385      |
| 1.2                               | 1.386                                 | 1.663               | 15.710                              | 18.852      |
| 1.3                               | 1.285                                 | 1.670               | 15.640                              | 20.332      |
| 1.4                               | 1.199                                 | 1.680               | 15.540                              | 21.756      |
| 1.5                               | 1.123                                 | 1.684               | 15.510                              | 23.265      |
| 1.6                               | 1.057                                 | 1.691               | 15.450                              | 24.720      |
| 1.7                               | 0.999                                 | 1.699               | 15.370                              | 26.129      |
| 1.8                               | 0.946                                 | 1.703               | 15.340                              | 27.612      |
| 1.9                               | 0.899                                 | 1.708               | 15.290                              | 29.051      |
| 2.0                               | 0.857                                 | 1.714               | 15.243                              | 30.486      |
| 2.1                               | 0.819                                 | 1.718               | 15.208                              | 31.937      |
| 2.2                               | 0.784                                 | 1.725               | 15.146                              | 33.321      |
| 2.3                               | 0.751                                 | 1.727               | 15.128                              | 34.794      |
| 2.4                               | 0.722                                 | 1.733               | 15.076                              | 36.182      |
| 2.5                               | 0.695                                 | 1.741               | 15.002                              | 37.505      |
| 2.6                               | 0.670                                 | 1.742               | 14.990                              | 38.974      |
| 2.7                               | 0.646                                 | 1.744               | 14.970                              | 40.190      |
| 2.8                               | 0.625                                 | 1.750               | 14.929                              | 41.801      |
| 2.9                               | 0.604                                 | 1.752               | 14.921                              | 43.271      |
| 3.0                               | 0.586                                 | 1.758               | 14.861                              | 44.583      |
| 3.1                               | 0.568                                 | 1.761               | 14.838                              | 45.998      |
| 3.2                               | 0.551                                 | 1.763               | 14.818                              | 47.417      |
| 3.3                               | 0.535                                 | 1.765               | 14.790                              | 48.807      |
| 3.4                               | 0.521                                 | 1.771               | 14.749                              | 50.146      |
| 3.5                               | 0.507                                 | 1.774               | 14.723                              | 51.330      |
| 3.6                               | 0.493                                 | 1.775               | 14.720                              | 52.992      |
| 3.7                               | 0.481                                 | 1.780               | 14.680                              | 54.316      |
| 3.8                               | 0.469                                 | 1.782               | 14.660                              | 55.708      |
| 3.9                               | 0.458                                 | 1.786               | 14.630                              | 57.057      |
| 4.0                               | 0.447                                 | 1.788               | 14.61                               | 58.440      |
| 4.1                               | 0.437                                 | 1.792               | 14.58                               | 59.778      |
| 4.2                               | 0.427                                 | 1.793               | 14.56                               | 61.152      |
| 4.3                               | 0.418                                 | 1.797               | 14.53                               | 62.479      |
| 4.4                               | 0.409                                 | 1.799               | 14.52                               | 63.888      |

METRIC STEAM AND WORK TABLE—Continued.

| Absolute pressure $p_a$ in Atmospheres. | Specific volumes $v_g$ in Cu. meters. | Product $p_a v_g$ . | $W = \frac{26127.34}{1000 p_a v_g}$ | W. $p_a$ . |
|---|---------------------------------------|---------------------|-------------------------------------|------------|
| 4.5                                     | 0.400                                 | 1.800               | 14.51                               | 65.295     |
| 4.6                                     | 0.392                                 | 1.803               | 14.49                               | 66.654     |
| 4.7                                     | 0.384                                 | 1.805               | 14.45                               | 67.915     |
| 4.8                                     | 0.377                                 | 1.810               | 14.43                               | 69.264     |
| 4.9                                     | 0.370                                 | 1.813               | 14.41                               | 70.609     |
| 5.0                                     | 0.363                                 | 1.815               | 14.39                               | 71.950     |
| 5.1                                     | 0.356                                 | 1.816               | 14.38                               | 73.338     |
| 5.2                                     | 0.350                                 | 1.820               | 14.36                               | 74.672     |
| 5.3                                     | 0.343                                 | 1.821               | 14.35                               | 76.055     |
| 5.4                                     | 0.337                                 | 1.823               | 14.33                               | 77.382     |
| 5.5                                     | 0.332                                 | 1.825               | 14.31                               | 78.705     |
| 5.6                                     | 0.326                                 | 1.826               | 14.30                               | 80.080     |
| 5.7                                     | 0.321                                 | 1.829               | 14.26                               | 81.282     |
| 5.8                                     | 0.316                                 | 1.833               | 14.25                               | 82.650     |
| 5.9                                     | 0.311                                 | 1.835               | 14.24                               | 84.016     |
| 6.0                                     | 0.306                                 | 1.836               | 14.23                               | 85.380     |
| 6.25                                    | 0.294                                 | 1.838               | 14.21                               | 88.812     |
| 6.5                                     | 0.284                                 | 1.845               | 14.16                               | 92.040     |
| 6.75                                    | 0.273                                 | 1.848               | 14.13                               | 95.377     |
| 7.0                                     | 0.265                                 | 1.855               | 14.10                               | 98.700     |
| 7.25                                    | 0.256                                 | 1.856               | 14.07                               | 100.997    |
| 7.5                                     | 0.248                                 | 1.860               | 14.04                               | 105.300    |
| 7.75                                    | 0.241                                 | 1.867               | 13.99                               | 108.422    |
| 8.0                                     | 0.234                                 | 1.872               | 13.96                               | 111.680    |
| 8.25                                    | 0.227                                 | 1.873               | 13.95                               | 114.077    |
| 8.5                                     | 0.221                                 | 1.878               | 13.91                               | 118.235    |
| 8.75                                    | 0.215                                 | 1.881               | 13.89                               | 121.537    |
| 9.0                                     | 0.209                                 | 1.883               | 13.86                               | 124.740    |
| 9.25                                    | 0.204                                 | 1.887               | 13.84                               | 128.020    |
| 9.5                                     | 0.199                                 | 1.891               | 13.81                               | 131.195    |
| 9.75                                    | 0.194                                 | 1.893               | 13.80                               | 134.550    |
| 10.0                                    | 0.190                                 | 1.900               | 13.75                               | 137.500    |



X. PROPERTIES OF SATURATED STEAM.

NOTE.—The following table gives the data required by the engineer in this connection as based upon the experiments of Regnault. The temperatures, pressures, and heat-measures are all from Regnault's experiments. The other quantities were calculated by Mr. R. H. Buel,\* adopting the formulas of Rankine already given to obtain quantities not ascertained by direct experiment. The two parts of the latent heat of vaporization are separately determined, and the internal thus distinguished from the external work of expansion. British measures are adopted. The nomenclature is sufficiently well explained by the table-headings.

| P<br>Pressure above a vacuum, in pounds | t<br>Temperature, Fahrenheit degrees. | QUANTITIES OF HEAT.  |                            |                            |  |   |        | U<br>Total heat of evaporation above 32°, in units of evaporation. | W<br>Weight of a cubic foot of steam, in pounds. | VOLUME.                                 |   |   |
|---|---------------------------------------|--|----------------------------|----------------------------|--|---|--------|--|--|---|---|---|
|   |                                       | In British Thermal Units.  |                            |                            |  |   |        |  |  | C<br>Of a pound of steam in cubic feet. | V<br>Volume of equal weight of distilled water at density of maximum density. | P<br>Pressure above a vacuum, in pounds |
|   |                                       | S<br>Required to raise the temperature of the water from 32° to 70°. | I<br>Internal latent heat. | E<br>External latent heat. | L<br>Latent heat of evaporation at pressure P = I + E. | H<br>Total heat of evaporation above 32° = S + L. | U      |  |  |   |   |   |
| 1                                       | 102.018                               | 70.040   | 981.396                    | 61.619                     | 1043.015   | 1113.055  | 1.1582 | .003027  | 330.4  | 20.623                                  | 1   |   |
| 2                                       | 126.302                               | 94.368   | 961.980                    | 64.114                     | 1026.094   | 1120.462  | 1.1599 | .003818  | 171.9  | 10.730                                  | 2   |   |
| 3                                       | 141.654                               | 109.764  | 949.725                    | 65.655                     | 1015.380   | 1125.144  | 1.1647 | .00522   | 117.3  | 7.325                                   | 3   |   |
| 4                                       | 153.122                               | 121.271  | 940.597                    | 66.773                     | 1007.370   | 1128.641  | 1.1683 | .011172  | 89.51  | 5.588                                   | 4   |   |
| 5                                       | 162.370                               | 130.563  | 933.239                    | 67.660                     | 1000.899   | 1131.462  | 1.1712 | .013781  | 72.56  | 4.530                                   | 5   |   |
| 6                                       | 170.173                               | 138.401  | 927.038                    | 68.403                     | 995.441  | 1133.842  | 1.1737 | .016357  | 61.14  | 3.816                                   | 6   |   |
| 7                                       | 176.945                               | 145.213  | 921.654                    | 69.041                     | 990.695  | 1135.908  | 1.1758 | .018908  | 52.89  | 3.302                                   | 7   |   |
| 8                                       | 182.052                               | 151.255  | 916.883                    | 69.685                     | 986.485  | 1137.740  | 1.1777 | .021436  | 46.65  | 2.912                                   | 8   |   |
| 9                                       | 188.357                               | 156.699  | 912.584                    | 70.106                     | 982.690  | 1139.369  | 1.1794 | .023944  | 41.77  | 2.607                                   | 9   |   |
| 10                                      | 193.284                               | 161.660  | 908.672                    | 70.560                     | 979.232  | 1140.692  | 1.1810 | .026437  | 37.83  | 2.361                                   | 10  |   |
| 11                                      | 197.84                                | 166.225  | 905.083                    | 70.967                     | 976.050  | 1142.275  | 1.1824 | .028911  | 34.59  | 2.159                                   | 11  |   |
| 12                                      | 202.012                               | 170.457  | 901.706                    | 71.332                     | 973.098  | 1143.555  | 1.1837 | .031376  | 31.87  | 1.990                                   | 12  |   |
| 13                                      | 205.959                               | 174.402  | 898.683                    | 71.663                     | 970.346  | 1144.748  | 1.1849 | .033838  | 29.56  | 1.845                                   | 13  |   |
| 14                                      | 209.604                               | 178.112  | 895.784                    | 71.973                     | 967.757  | 1145.860  | 1.1861 | .036265  | 27.58  | 1.721                                   | 14  |   |
| 14.69                                   | 212.000                               | 180.531  | 893.894                    | 72.175                     | 966.069  | 1146.600  | 1.1869 | .037928  | 26.37  | 1.646                                   | 14.69   |   |
| 15                                      | 213.067                               | 181.608  | 893.044                    | 72.274                     | 965.318  | 1146.926  | 1.1872 | .038688  | 25.85  | 1.614                                   | 15  |   |
| 16                                      | 216.347                               | 184.919  | 890.458                    | 72.540                     | 963.007  | 1147.926  | 1.1882 | .041109  | 24.33  | 1.513                                   | 16  |   |
| 17                                      | 219.452                               | 188.056  | 888.007                    | 72.811                     | 960.812  | 1148.874  | 1.1892 | .043519  | 22.98  | 1.434                                   | 17  |   |

\* Weisbach's Mechanics, vol. ii., part ii., Dubois' translation. N. Y.: J. Wiley & Sons. 1884.

| P  | t       | S       | I       | E      | L        | H        | U      | W       | C     | V     | P  |
|----|---------|---------|---------|--------|----------|----------|--------|---------|-------|-------|----|
| 18 | 222.484 | 191.038 | 885.661 | 73.060 | 928.721  | 1149.779 | 1.1901 | .045920 | 21.78 | 1.359 | 18 |
| 19 | 225.255 | 193.918 | 883.427 | 73.208 | 946.725  | 1150.643 | 1.1910 | .048312 | 20.70 | 1.292 | 19 |
| 20 | 227.964 | 196.655 | 881.289 | 73.525 | 954.814  | 1151.469 | 1.1919 | .050696 | 19.73 | 1.231 | 20 |
| 21 | 230.595 | 199.285 | 879.239 | 73.739 | 962.978  | 1152.269 | 1.1927 | .053074 | 18.84 | 1.176 | 21 |
| 22 | 233.066 | 201.817 | 877.267 | 73.942 | 971.209  | 1153.046 | 1.1935 | .055446 | 18.04 | 1.126 | 22 |
| 23 | 235.470 | 204.258 | 875.368 | 74.136 | 979.504  | 1153.762 | 1.1943 | .057812 | 17.30 | 1.080 | 23 |
| 24 | 237.803 | 206.610 | 873.538 | 74.323 | 987.861  | 1154.471 | 1.1950 | .060171 | 16.62 | 1.038 | 24 |
| 25 | 240.053 | 208.887 | 871.767 | 74.503 | 996.270  | 1155.157 | 1.1957 | .062524 | 16.00 | 998.4 | 25 |
| 26 | 242.225 | 211.089 | 870.052 | 74.678 | 1004.730 | 1155.819 | 1.1964 | .064870 | 15.43 | 962.3 | 26 |
| 27 | 244.333 | 213.223 | 868.391 | 74.847 | 1013.238 | 1156.461 | 1.1971 | .067210 | 14.88 | 928.8 | 27 |
| 28 | 246.370 | 215.293 | 866.780 | 75.011 | 1021.791 | 1157.084 | 1.1978 | .069545 | 14.38 | 896.5 | 28 |
| 29 | 248.353 | 217.308 | 865.215 | 75.168 | 1030.383 | 1157.691 | 1.1984 | .071875 | 13.91 | 867.5 | 29 |
| 30 | 250.293 | 219.261 | 863.700 | 75.319 | 1039.019 | 1158.286 | 1.1990 | .074201 | 13.48 | 841.3 | 30 |
| 31 | 252.171 | 221.165 | 862.221 | 75.466 | 1047.687 | 1158.852 | 1.1996 | .076522 | 13.07 | 815.8 | 31 |
| 32 | 254.002 | 223.021 | 860.781 | 75.608 | 1056.389 | 1159.410 | 1.2002 | .078839 | 12.68 | 791.8 | 32 |
| 33 | 255.782 | 224.827 | 859.382 | 75.745 | 1065.127 | 1159.954 | 1.2008 | .081152 | 12.32 | 769.2 | 33 |
| 34 | 257.523 | 226.594 | 858.013 | 75.878 | 1073.901 | 1160.485 | 1.2013 | .083461 | 11.98 | 748.0 | 34 |
| 35 | 259.221 | 228.316 | 856.680 | 76.007 | 1082.687 | 1161.003 | 1.2018 | .085766 | 11.66 | 727.0 | 35 |
| 36 | 260.883 | 230.001 | 855.375 | 76.133 | 1091.508 | 1161.509 | 1.2023 | .088067 | 11.36 | 708.8 | 36 |
| 37 | 262.505 | 231.650 | 854.099 | 76.255 | 1100.354 | 1162.004 | 1.2028 | .090364 | 11.07 | 690.8 | 37 |
| 38 | 264.093 | 233.261 | 852.852 | 76.373 | 1109.227 | 1162.488 | 1.2033 | .092657 | 10.79 | 673.7 | 38 |
| 39 | 265.647 | 234.840 | 851.629 | 76.483 | 1118.122 | 1162.962 | 1.2038 | .094946 | 10.53 | 657.5 | 39 |
| 40 | 267.168 | 236.386 | 850.432 | 76.668 | 1127.040 | 1163.426 | 1.2043 | .097231 | 10.28 | 642.0 | 40 |
| 41 | 268.660 | 237.902 | 849.261 | 76.719 | 1135.980 | 1163.882 | 1.2048 | .099514 | 10.05 | 627.3 | 41 |
| 42 | 270.122 | 239.389 | 848.113 | 76.827 | 1144.940 | 1164.329 | 1.2053 | .101794 | 9.826 | 613.3 | 42 |
| 43 | 271.557 | 240.846 | 846.988 | 76.932 | 1153.920 | 1164.766 | 1.2058 | .104071 | 9.609 | 599.9 | 43 |
| 44 | 272.965 | 242.275 | 845.884 | 77.035 | 1162.919 | 1165.194 | 1.2062 | .106345 | 9.403 | 587.0 | 44 |
| 45 | 274.347 | 243.680 | 844.700 | 77.136 | 1171.935 | 1165.615 | 1.2066 | .108616 | 9.207 | 574.7 | 45 |
| 46 | 275.704 | 245.061 | 843.533 | 77.235 | 1181.668 | 1166.029 | 1.2070 | .110884 | 9.018 | 563.0 | 46 |
| 47 | 277.036 | 246.418 | 842.387 | 77.331 | 1191.418 | 1166.436 | 1.2074 | .113149 | 8.838 | 551.7 | 47 |
| 48 | 278.348 | 247.752 | 841.259 | 77.425 | 1201.184 | 1166.836 | 1.2078 | .115411 | 8.665 | 540.9 | 48 |
| 49 | 279.637 | 249.064 | 840.147 | 77.517 | 1210.964 | 1167.228 | 1.2082 | .117670 | 8.498 | 530.5 | 49 |
| 50 | 280.904 | 250.355 | 839.053 | 77.607 | 1220.760 | 1167.615 | 1.2086 | .119927 | 8.338 | 520.5 | 50 |
| 51 | 282.151 | 251.624 | 838.075 | 77.696 | 1230.571 | 1167.995 | 1.2090 | .122181 | 8.185 | 510.9 | 51 |
| 52 | 283.381 | 252.875 | 837.200 | 77.784 | 1240.399 | 1168.369 | 1.2094 | .124433 | 8.037 | 501.7 | 52 |
| 53 | 284.589 | 254.106 | 836.762 | 77.870 | 1250.238 | 1168.738 | 1.2098 | .126682 | 7.894 | 492.8 | 53 |
| 54 | 285.781 | 255.321 | 835.827 | 77.954 | 1260.102 | 1169.102 | 1.2102 | .128928 | 7.756 | 484.2 | 54 |
| 55 | 286.955 | 256.518 | 834.906 | 78.036 | 1270.004 | 1169.460 | 1.2106 | .131172 | 7.624 | 475.9 | 55 |
| 56 | 288.111 | 257.695 | 834.001 | 78.118 | 1280.018 | 1169.813 | 1.2110 | .133414 | 7.496 | 467.9 | 56 |
| 57 | 289.251 | 258.857 | 833.108 | 78.196 | 1290.161 | 1170.161 | 1.2114 | .135654 | 7.372 | 460.2 | 57 |

PROPERTIES OF SATURATED STEAM—(Continued).

| Pressure above a vacuum, in pounds | Temperature, Fahrenheit degrees. | QUANTITIES OF HEAT.  |                       |                       |   |  |        |         | Total heat of evaporation above 32° in units of evaporation. | Weight of a cubic foot of steam, in pounds. | VOLUME.                            |  |                                    |
|------------------------------------|----------------------------------|--|-----------------------|-----------------------|---|--|--------|---------|--|---|------------------------------------|--|------------------------------------|
|                                    |                                  | In British Thermal Units.                                      |                       |                       |   |  |        |         |  |   | Of a pound of steam in cubic feet. | Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density. | Pressure above a vacuum, in pounds |
|                                    |                                  | Required to raise the temperature of the water from 32° to T°. | Internal latent heat. | External latent heat. | Latent heat of evaporation at pressure P = I + L. | Total heat of evaporation above 32° = S + L. | E      | L       |  |   |                                    |  |                                    |
| 58                                 | 290.374                          | 260.002  | 832.228               | 78.273                | 910.501   | 1170.503                                     | 1.2117 | .137852 | 7.252  | 452.7                                       | 58                                 |  |                                    |
| 59                                 | 291.483                          | 261.132  | 831.361               | 78.346                | 909.709   | 1170.841                                     | 1.2120 | .140128 | 7.136  | 445.5                                       | 59                                 |  |                                    |
| 60                                 | 292.575                          | 262.248  | 830.507               | 78.421                | 908.928   | 1171.176                                     | 1.2123 | .142362 | 7.024  | 438.5                                       | 60                                 |  |                                    |
| 61                                 | 293.653                          | 263.348  | 829.663               | 78.494                | 908.157   | 1171.505                                     | 1.2127 | .144594 | 6.916  | 431.7                                       | 61                                 |  |                                    |
| 62                                 | 294.717                          | 264.433  | 828.830               | 78.566                | 907.396   | 1171.829                                     | 1.2130 | .146824 | 6.811  | 425.0                                       | 62                                 |  |                                    |
| 63                                 | 295.768                          | 265.506  | 828.005               | 78.638                | 906.643   | 1172.149                                     | 1.2133 | .149052 | 6.709  | 418.8                                       | 63                                 |  |                                    |
| 64                                 | 296.805                          | 266.566  | 827.191               | 78.709                | 905.900   | 1172.466                                     | 1.2136 | .151277 | 6.610  | 412.6                                       | 64                                 |  |                                    |
| 65                                 | 297.830                          | 267.612  | 826.388               | 78.779                | 905.167   | 1172.779                                     | 1.2140 | .153500 | 6.515  | 406.6                                       | 65                                 |  |                                    |
| 66                                 | 298.842                          | 268.644  | 825.596               | 78.847                | 904.443   | 1173.087                                     | 1.2143 | .155721 | 6.422  | 400.8                                       | 66                                 |  |                                    |
| 67                                 | 299.843                          | 269.666  | 824.814               | 78.913                | 903.727   | 1173.393                                     | 1.2146 | .157940 | 6.332  | 395.2                                       | 67                                 |  |                                    |
| 68                                 | 300.831                          | 270.674  | 824.042               | 78.978                | 903.020   | 1173.694                                     | 1.2149 | .160157 | 6.244  | 389.8                                       | 68                                 |  |                                    |
| 69                                 | 301.807                          | 271.669  | 823.280               | 79.042                | 902.322   | 1173.984                                     | 1.2152 | .162372 | 6.159  | 384.5                                       | 69                                 |  |                                    |
| 70                                 | 302.774                          | 272.657  | 822.524               | 79.105                | 901.629   | 1174.286                                     | 1.2155 | .164584 | 6.076  | 379.3                                       | 70                                 |  |                                    |
| 71                                 | 303.728                          | 273.633  | 821.778               | 79.167                | 900.945   | 1174.578                                     | 1.2158 | .166794 | 5.995  | 374.3                                       | 71                                 |  |                                    |
| 72                                 | 304.669                          | 274.597  | 821.041               | 79.228                | 900.269   | 1174.866                                     | 1.2161 | .169003 | 5.917  | 369.4                                       | 72                                 |  |                                    |
| 73                                 | 305.603                          | 275.550  | 820.312               | 79.288                | 899.600   | 1175.150                                     | 1.2164 | .171210 | 5.841  | 364.6                                       | 73                                 |  |                                    |
| 74                                 | 306.526                          | 276.493  | 819.589               | 79.349                | 898.938   | 1175.431                                     | 1.2167 | .173417 | 5.767  | 360.0                                       | 74                                 |  |                                    |
| 75                                 | 307.440                          | 277.427  | 818.873               | 79.410                | 898.283   | 1175.710                                     | 1.2170 | .175622 | 5.694  | 355.5                                       | 75                                 |  |                                    |
| 76                                 | 308.344                          | 278.350  | 818.166               | 79.469                | 897.635   | 1175.985                                     | 1.2173 | .177825 | 5.624  | 351.1                                       | 76                                 |  |                                    |

| P   | t       | S       | I       | E      | L       | H        | U      | W       | C     | V     | P   |
|-----|---------|---------|---------|--------|---------|----------|--------|---------|-------|-------|-----|
| 77  | 300.239 | 270.265 | 817.468 | 79.586 | 806.994 | 1176.239 | 1.2176 | .180027 | 5.555 | 346.8 | 77  |
| 78  | 310.123 | 280.170 | 816.095 | 79.582 | 806.339 | 1176.589 | 1.2179 | .182293 | 5.488 | 342.6 | 78  |
| 79  | 311.000 | 281.066 | 815.413 | 79.539 | 805.729 | 1176.795 | 1.2181 | .184429 | 5.422 | 338.5 | 79  |
| 80  | 311.866 | 281.932 | 814.742 | 79.695 | 805.108 | 1177.066 | 1.2184 | .186627 | 5.358 | 334.5 | 80  |
| 81  | 312.725 | 282.830 | 814.077 | 79.749 | 804.491 | 1177.321 | 1.2187 | .188823 | 5.296 | 330.6 | 81  |
| 82  | 313.576 | 283.701 | 813.419 | 79.802 | 803.879 | 1177.580 | 1.2190 | .191017 | 5.235 | 326.8 | 82  |
| 83  | 314.417 | 284.562 | 812.768 | 79.856 | 803.275 | 1177.837 | 1.2193 | .193210 | 5.176 | 323.1 | 83  |
| 84  | 315.250 | 285.414 | 812.122 | 79.909 | 802.677 | 1178.091 | 1.2195 | .195401 | 5.118 | 319.5 | 84  |
| 85  | 316.076 | 286.266 | 811.484 | 79.961 | 802.083 | 1178.343 | 1.2198 | .197591 | 5.061 | 315.9 | 85  |
| 86  | 316.893 | 287.106 | 810.850 | 80.012 | 801.495 | 1178.592 | 1.2200 | .199781 | 5.006 | 312.5 | 86  |
| 87  | 317.705 | 287.927 | 810.222 | 80.063 | 800.913 | 1178.840 | 1.2203 | .201969 | 4.951 | 309.1 | 87  |
| 88  | 318.510 | 288.738 | 809.601 | 80.113 | 800.335 | 1179.085 | 1.2205 | .204155 | 4.898 | 305.8 | 88  |
| 89  | 319.306 | 289.535 | 808.986 | 80.162 | 800.763 | 1179.328 | 1.2208 | .206340 | 4.846 | 302.5 | 89  |
| 90  | 320.094 | 290.323 | 808.375 | 80.210 | 800.190 | 1179.569 | 1.2210 | .208525 | 4.796 | 299.4 | 90  |
| 91  | 320.877 | 291.106 | 807.770 | 80.258 | 800.633 | 1179.809 | 1.2212 | .210709 | 4.746 | 296.3 | 91  |
| 92  | 321.653 | 291.976 | 807.170 | 80.305 | 800.075 | 1180.045 | 1.2215 | .212892 | 4.697 | 293.2 | 92  |
| 93  | 322.422 | 292.758 | 806.571 | 80.351 | 800.521 | 1180.279 | 1.2217 | .215074 | 4.650 | 290.2 | 93  |
| 94  | 323.183 | 293.539 | 805.985 | 80.397 | 800.972 | 1180.511 | 1.2220 | .217253 | 4.603 | 287.3 | 94  |
| 95  | 323.939 | 294.314 | 805.400 | 80.442 | 800.427 | 1180.741 | 1.2222 | .219430 | 4.557 | 284.5 | 95  |
| 96  | 324.688 | 295.083 | 804.821 | 80.487 | 800.887 | 1180.970 | 1.2224 | .221604 | 4.513 | 281.7 | 96  |
| 97  | 325.431 | 295.845 | 804.245 | 80.531 | 800.352 | 1181.197 | 1.2227 | .223778 | 4.469 | 279.0 | 97  |
| 98  | 326.169 | 296.601 | 803.675 | 80.576 | 800.821 | 1181.422 | 1.2229 | .225950 | 4.426 | 276.3 | 98  |
| 99  | 326.900 | 297.359 | 803.108 | 80.620 | 800.295 | 1181.645 | 1.2232 | .228122 | 4.384 | 273.7 | 99  |
| 100 | 327.625 | 298.103 | 802.544 | 80.665 | 800.773 | 1181.866 | 1.2234 | .230293 | 4.342 | 271.1 | 100 |
| 101 | 328.345 | 298.832 | 801.985 | 80.709 | 800.253 | 1182.085 | 1.2236 | .232464 | 4.302 | 268.5 | 101 |
| 102 | 329.060 | 299.566 | 801.432 | 80.753 | 800.737 | 1182.303 | 1.2238 | .234634 | 4.262 | 266.0 | 102 |
| 103 | 329.779 | 300.293 | 800.884 | 80.794 | 800.220 | 1182.519 | 1.2240 | .236803 | 4.223 | 263.6 | 103 |
| 104 | 330.471 | 301.014 | 800.339 | 80.835 | 801.719 | 1182.733 | 1.2242 | .238972 | 4.185 | 261.2 | 104 |
| 105 | 331.169 | 301.731 | 799.796 | 80.875 | 801.214 | 1182.945 | 1.2245 | .241139 | 4.147 | 258.9 | 105 |
| 106 | 331.862 | 302.444 | 799.258 | 80.916 | 800.712 | 1183.156 | 1.2247 | .243304 | 4.110 | 256.6 | 106 |
| 107 | 332.550 | 303.152 | 798.725 | 80.956 | 800.214 | 1183.366 | 1.2249 | .245467 | 4.074 | 254.3 | 107 |
| 108 | 333.232 | 303.854 | 798.196 | 80.995 | 800.720 | 1183.574 | 1.2251 | .247629 | 4.038 | 252.1 | 108 |
| 109 | 333.911 | 304.551 | 797.672 | 81.034 | 800.230 | 1183.781 | 1.2254 | .249789 | 4.003 | 249.9 | 109 |
| 110 | 334.582 | 305.242 | 797.153 | 81.072 | 800.744 | 1183.986 | 1.2256 | .251947 | 3.969 | 247.8 | 110 |
| 111 | 335.250 | 305.927 | 796.637 | 81.110 | 800.263 | 1184.190 | 1.2258 | .254105 | 3.935 | 245.7 | 111 |
| 112 | 335.914 | 306.609 | 796.125 | 81.147 | 800.780 | 1184.393 | 1.2260 | .256263 | 3.902 | 243.6 | 112 |
| 113 | 336.577 | 307.285 | 795.617 | 81.184 | 800.300 | 1184.594 | 1.2262 | .258420 | 3.870 | 241.6 | 113 |
| 114 | 337.226 | 307.956 | 795.114 | 81.221 | 800.818 | 1184.794 | 1.2264 | .260576 | 3.838 | 239.6 | 114 |
| 115 | 337.874 | 308.621 | 794.614 | 81.257 | 800.337 | 1184.988 | 1.2266 | .262731 | 3.806 | 237.6 | 115 |
| 116 | 338.518 | 309.281 | 794.114 | 81.293 | 800.855 | 1185.188 | 1.2268 | .264887 | 3.775 | 235.7 | 116 |
| 117 | 339.159 | 309.939 | 793.614 | 81.330 | 800.373 | 1185.383 | 1.2270 | .267041 | 3.745 | 233.8 | 117 |



PROPERTIES OF SATURATED STEAM—(Continued).

| P<br>Pressure above a vacuum, in pounds | t<br>Temperature, Fahrenheit degrees. | QUANTITIES OF HEAT.   |                            |                            |  |   |        | U<br>Total heat of evaporation above 32°, in units of evaporation. | W<br>Weight of a cubic foot of steam, in pounds. | C<br>Of a pound of steam in cubic feet. | VOLUME.   |  | P<br>Pressure above a vacuum, in pounds per square inch. |
|---|---------------------------------------|---|----------------------------|----------------------------|--|---|--------|--|--|---|---|--|--|
|   |                                       | In British Thermal Units.   |                            |                            |  |   |        |  |  |   | V<br>Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density. | V<br>Volume of steam to volume of equal weight of distilled water at temperature of maximum density. |  |
|   |                                       | S<br>Required to raise the temperature of the water from 32° to P°. | I<br>Internal latent heat. | E<br>External latent heat. | L<br>Latent heat of evaporation at pressure P = I + E. | H<br>Total heat of evaporation above 32° = S + L. |        |  |  |   |   |  |  |
| 118                                     | 330.796                               | 310.592   | 793.619                    | 81.366                     | 874.985  | 1185.577  | 1.2272 | .260195  | 5.715  | 231.9                                   | 118   |  |  |
| 119                                     | 340.430                               | 311.241   | 793.126                    | 81.493                     | 874.520  | 1185.770  | 1.2274 | .271318  | 3.685  | 230.1                                   | 119   |  |  |
| 120                                     | 341.058                               | 311.885   | 792.637                    | 81.439                     | 874.076  | 1185.961  | 1.2276 | .273500  | 3.650  | 228.3                                   | 120   |  |  |
| 121                                     | 341.681                               | 312.524   | 792.152                    | 81.474                     | 873.626  | 1186.150  | 1.2278 | .275651  | 3.628  | 226.5                                   | 121   |  |  |
| 122                                     | 342.300                               | 313.161   | 791.669                    | 81.599                     | 873.178  | 1186.339  | 1.2280 | .277801  | 3.600  | 224.7                                   | 122   |  |  |
| 123                                     | 342.916                               | 313.795   | 791.189                    | 81.543                     | 872.732  | 1186.527  | 1.2282 | .279949  | 3.572  | 223.0                                   | 123   |  |  |
| 124                                     | 343.528                               | 314.425   | 790.711                    | 81.578                     | 872.289  | 1186.714  | 1.2284 | .282097  | 3.545  | 221.3                                   | 124   |  |  |
| 125                                     | 344.136                               | 315.051   | 790.236                    | 81.612                     | 871.848  | 1186.899  | 1.2286 | .284243  | 3.518  | 219.6                                   | 125   |  |  |
| 126                                     | 344.741                               | 315.672   | 789.765                    | 81.646                     | 871.411  | 1187.083  | 1.2288 | .286389  | 3.492  | 218.0                                   | 126   |  |  |
| 127                                     | 345.340                               | 316.289   | 789.298                    | 81.679                     | 870.977  | 1187.266  | 1.2290 | .288533  | 3.466  | 216.4                                   | 127   |  |  |
| 128                                     | 345.936                               | 316.903   | 788.834                    | 81.711                     | 870.545  | 1187.448  | 1.2292 | .290677  | 3.440  | 214.8                                   | 128   |  |  |
| 129                                     | 346.530                               | 317.513   | 788.374                    | 81.742                     | 870.116  | 1187.629  | 1.2293 | .292820  | 3.415  | 213.2                                   | 129   |  |  |
| 130                                     | 347.121                               | 318.121   | 787.914                    | 81.774                     | 869.688  | 1187.809  | 1.2295 | .294961  | 3.390  | 211.6                                   | 130   |  |  |
| 131                                     | 347.706                               | 318.725   | 787.458                    | 81.805                     | 869.263  | 1187.988  | 1.2296 | .297102  | 3.366  | 210.1                                   | 131   |  |  |
| 132                                     | 348.287                               | 319.325   | 787.004                    | 81.837                     | 868.841  | 1188.166  | 1.2298 | .299242  | 3.342  | 208.6                                   | 132   |  |  |
| 133                                     | 348.867                               | 319.922   | 786.554                    | 81.868                     | 868.422  | 1188.344  | 1.2300 | .301382  | 3.318  | 207.1                                   | 133   |  |  |
| 134                                     | 349.443                               | 320.515   | 786.105                    | 81.900                     | 868.005  | 1188.520  | 1.2302 | .303521  | 3.295  | 205.7                                   | 134   |  |  |
| 135                                     | 350.015                               | 321.105   | 785.659                    | 81.931                     | 867.590  | 1188.695  | 1.2304 | .305659  | 3.272  | 204.2                                   | 135   |  |  |
| 136                                     | 350.584                               | 321.692   | 785.215                    | 81.962                     | 867.177  | 1188.869  | 1.2306 | .307797  | 3.249  | 202.8                                   | 136   |  |  |
| 137                                     | 351.149                               | 322.274   | 784.775                    | 81.992                     | 866.767  | 1189.041  | 1.2308 | .309934  | 3.227  | 201.4                                   | 137   |  |  |
| 138                                     | 351.711                               | 322.853   | 784.339                    | 82.021                     | 866.360  | 1189.213  | 1.2309 | .312070  | 3.204  | 200.0                                   | 138   |  |  |



| P    | t       | S       | I       | E      | L        | H        | U      | W        | C     | V     | P    |
|------|---------|---------|---------|--------|----------|----------|--------|----------|-------|-------|------|
| 136  | 352.271 | 323.429 | 783.095 | 82.050 | 265.955  | 1189.384 | 1.2311 | .314205  | 3.182 | 198.7 | 139  |
| 140  | 352.827 | 324.003 | 783.472 | 82.080 | 80.5.552 | 1189.555 | 1.2313 | .316338  | 3.161 | 197.3 | 140  |
| 141  | 353.380 | 324.573 | 783.042 | 82.109 | 86.5.151 | 1189.724 | 1.2315 | .318471  | 3.140 | 196.0 | 141  |
| 142  | 353.931 | 325.141 | 782.613 | 82.138 | 86.4.751 | 1189.892 | 1.2316 | .320603  | 3.119 | 194.7 | 142  |
| 143  | 354.478 | 325.705 | 782.188 | 82.166 | 86.4.354 | 1190.059 | 1.2318 | .322735  | 3.099 | 193.4 | 143  |
| 144  | 355.022 | 326.265 | 781.766 | 82.194 | 86.3.960 | 1190.225 | 1.2320 | .324867  | 3.078 | 192.2 | 144  |
| 145  | 355.562 | 326.823 | 781.346 | 82.221 | 86.3.567 | 1190.390 | 1.2321 | .326998  | 3.058 | 190.9 | 145  |
| 146  | 356.109 | 327.378 | 780.927 | 82.249 | 86.3.176 | 1190.554 | 1.2323 | .329128  | 3.038 | 189.7 | 146  |
| 147  | 356.636 | 327.930 | 780.510 | 82.277 | 86.2.787 | 1190.717 | 1.2324 | .331257  | 3.019 | 188.5 | 147  |
| 148  | 357.169 | 328.479 | 780.096 | 82.304 | 86.2.400 | 1190.879 | 1.2326 | .333386  | 3.000 | 187.3 | 148  |
| 149  | 357.697 | 329.024 | 779.684 | 82.332 | 86.2.016 | 1191.040 | 1.2328 | .335515  | 2.981 | 186.1 | 149  |
| 150  | 358.223 | 329.566 | 779.275 | 82.359 | 86.1.634 | 1191.200 | 1.2330 | .337643  | 2.962 | 184.9 | 150  |
| 160  | 363.345 | 334.850 | 775.206 | 82.616 | 857.912  | 1192.762 | 1.2346 | .358886  | 2.786 | 173.9 | 160  |
| 170  | 368.226 | 339.892 | 771.505 | 82.854 | 854.359  | 1194.251 | 1.2361 | .380071  | 2.631 | 164.3 | 170  |
| 180  | 372.886 | 344.708 | 767.861 | 83.072 | 850.963  | 1195.671 | 1.2376 | .401201  | 2.493 | 155.6 | 180  |
| 190  | 377.352 | 349.329 | 764.430 | 83.273 | 847.793  | 1197.032 | 1.2390 | .422280  | 2.368 | 147.8 | 190  |
| 200  | 381.636 | 353.766 | 761.111 | 83.462 | 844.573  | 1198.339 | 1.2404 | .443310  | 2.255 | 140.8 | 200  |
| 210  | 385.759 | 358.041 | 757.016 | 83.640 | 841.556  | 1199.597 | 1.2417 | .464295  | 2.154 | 134.5 | 210  |
| 220  | 389.736 | 362.168 | 754.834 | 83.808 | 838.642  | 1200.810 | 1.2430 | .485237  | 2.061 | 128.7 | 220  |
| 230  | 393.575 | 366.152 | 751.862 | 83.966 | 835.828  | 1201.980 | 1.2442 | .506139  | 1.976 | 123.3 | 230  |
| 240  | 397.285 | 370.008 | 748.988 | 84.115 | 833.103  | 1203.111 | 1.2454 | .527003  | 1.898 | 118.5 | 240  |
| 250  | 400.883 | 373.750 | 746.203 | 84.250 | 830.459  | 1204.209 | 1.2465 | .547831  | 1.825 | 114.8 | 250  |
| 260  | 404.370 | 377.377 | 743.508 | 84.388 | 827.860  | 1205.273 | 1.2476 | .568626  | 1.759 | 109.8 | 260  |
| 270  | 407.755 | 380.905 | 740.861 | 84.510 | 825.401  | 1206.306 | 1.2487 | .589390  | 1.697 | 105.9 | 270  |
| 280  | 411.048 | 384.337 | 738.350 | 84.623 | 823.073  | 1207.310 | 1.2497 | .610124  | 1.639 | 102.3 | 280  |
| 290  | 414.250 | 387.677 | 735.878 | 84.731 | 820.609  | 1208.286 | 1.2507 | .630829  | 1.585 | 99.0  | 290  |
| 300  | 417.371 | 390.933 | 733.470 | 84.835 | 818.305  | 1209.238 | 1.2517 | .651506  | 1.535 | 95.8  | 300  |
| 350  | 431.96  | 406.86  | 722.20  | 85.28  | 807.48   | 1213.74  | 1.256  | .754534  | 1.325 | 82.7  | 350  |
| 400  | 444.92  | 419.76  | 712.32  | 85.60  | 797.04   | 1217.70  | 1.260  | .857185  | 1.167 | 72.8  | 400  |
| 450  | 456.62  | 432.18  | 703.28  | 85.84  | 789.12   | 1221.30  | 1.264  | .959536  | 1.042 | 65.1  | 450  |
| 500  | 467.42  | 443.52  | 695.01  | 86.01  | 781.02   | 1224.54  | 1.267  | 1.061700 | .942  | 58.8  | 500  |
| 550  | 477.50  | 454.44  | 687.34  | 86.12  | 773.46   | 1227.60  | 1.270  | 1.16380  | .859  | 53.6  | 550  |
| 600  | 486.86  | 464.22  | 680.68  | 86.18  | 766.20   | 1230.48  | 1.273  | 1.26586  | .790  | 49.3  | 600  |
| 650  | 495.68  | 473.58  | 673.40  | 86.20  | 759.66   | 1233.18  | 1.276  | 1.36791  | .731  | 45.2  | 650  |
| 700  | 504.14  | 482.40  | 667.11  | 86.19  | 753.30   | 1235.70  | 1.279  | 1.46995  | .680  | 41.4  | 700  |
| 750  | 512.06  | 490.86  | 661.04  | 86.14  | 747.18   | 1238.04  | 1.282  | 1.57198  | .630  | 39.0  | 750  |
| 800  | 519.62  | 498.88  | 665.34  | 86.08  | 741.42   | 1240.30  | 1.285  | 1.67401  | .597  | 37.1  | 800  |
| 850  | 526.82  | 506.66  | 649.84  | 86.00  | 735.84   | 1242.50  | 1.287  | 1.77603  | .563  | 34.9  | 850  |
| 900  | 533.66  | 514.03  | 644.71  | 85.91  | 730.62   | 1244.65  | 1.289  | 1.87804  | .532  | 33.0  | 900  |
| 950  | 540.32  | 521.30  | 639.60  | 85.80  | 725.40   | 1246.70  | 1.291  | 1.98004  | .505  | 31.4  | 950  |
| 1000 | 546.80  | 528.30  | 634.68  | 85.68  | 720.30   | 1248.65  | 1.293  | 2.08203  | .480  | 30.0  | 1000 |

The column headed "U" in the table of the properties of saturated steam is useful for reducing the performance of different boilers to a common standard—this standard being that most generally accepted by engineers: the equivalent evaporation at atmospheric pressure and the temperature of boiling water, or, as it is frequently called, the evaporation from and at 212°. In the table it is assumed that the temperature of the feed-water is 32°, and an auxiliary table is added, giving corrections for any temperature of feed from 32° to 212°.

## CORRECTION FOR TOTAL HEAT IN UNITS OF EVAPORATION.

| Temperature of feed, Fahrenheit degrees. | Correction. | Temperature of feed, Fahrenheit degrees. | Correction. | Temperature of feed, Fahrenheit degrees. | Correction. | Temperature of feed, Fahrenheit degrees. | Correction. | Temperature of feed, Fahrenheit degrees. | Correction. |
|--|-------------|--|-------------|--|-------------|--|-------------|--|-------------|
| 33                                       | .0010       | 69                                       | .0383       | 105                                      | .0756       | 141                                      | .1129       | 177                                      | .1504       |
| 34                                       | .0021       | 70                                       | .0393       | 106                                      | .0766       | 142                                      | .1140       | 178                                      | .1514       |
| 35                                       | .0031       | 71                                       | .0404       | 107                                      | .0777       | 143                                      | .1150       | 179                                      | .1525       |
| 36                                       | .0041       | 72                                       | .0414       | 108                                      | .0787       | 144                                      | .1160       | 180                                      | .1535       |
| 37                                       | .0052       | 73                                       | .0424       | 109                                      | .0797       | 145                                      | .1171       | 181                                      | .1545       |
| 38                                       | .0062       | 74                                       | .0435       | 110                                      | .0808       | 146                                      | .1181       | 182                                      | .1556       |
| 39                                       | .0073       | 75                                       | .0445       | 111                                      | .0818       | 147                                      | .1192       | 183                                      | .1566       |
| 40                                       | .0083       | 76                                       | .0455       | 112                                      | .0829       | 148                                      | .1202       | 184                                      | .1577       |
| 41                                       | .0093       | 77                                       | .0466       | 113                                      | .0839       | 149                                      | .1213       | 185                                      | .1587       |
| 42                                       | .0104       | 78                                       | .0476       | 114                                      | .0849       | 150                                      | .1223       | 186                                      | .1598       |
| 43                                       | .0114       | 79                                       | .0487       | 115                                      | .0860       | 151                                      | .1233       | 187                                      | .1608       |
| 44                                       | .0124       | 80                                       | .0497       | 116                                      | .0870       | 152                                      | .1244       | 188                                      | .1618       |
| 45                                       | .0135       | 81                                       | .0507       | 117                                      | .0880       | 153                                      | .1254       | 189                                      | .1629       |
| 46                                       | .0145       | 82                                       | .0518       | 118                                      | .0891       | 154                                      | .1264       | 190                                      | .1639       |
| 47                                       | .0155       | 83                                       | .0528       | 119                                      | .0901       | 155                                      | .1275       | 191                                      | .1650       |
| 48                                       | .0166       | 84                                       | .0538       | 120                                      | .0911       | 156                                      | .1285       | 192                                      | .1660       |
| 49                                       | .0176       | 85                                       | .0549       | 121                                      | .0922       | 157                                      | .1296       | 193                                      | .1670       |
| 50                                       | .0186       | 86                                       | .0559       | 122                                      | .0932       | 158                                      | .1306       | 194                                      | .1681       |
| 51                                       | .0197       | 87                                       | .0569       | 123                                      | .0943       | 159                                      | .1316       | 195                                      | .1691       |
| 52                                       | .0207       | 88                                       | .0580       | 124                                      | .0953       | 160                                      | .1327       | 196                                      | .1702       |
| 53                                       | .0217       | 89                                       | .0590       | 125                                      | .0963       | 161                                      | .1337       | 197                                      | .1712       |
| 54                                       | .0228       | 90                                       | .0601       | 126                                      | .0974       | 162                                      | .1348       | 198                                      | .1723       |
| 55                                       | .0238       | 91                                       | .0611       | 127                                      | .0984       | 163                                      | .1358       | 199                                      | .1733       |
| 56                                       | .0248       | 92                                       | .0621       | 128                                      | .0994       | 164                                      | .1368       | 200                                      | .1743       |
| 57                                       | .0259       | 93                                       | .0632       | 129                                      | .1005       | 165                                      | .1379       | 201                                      | .1754       |
| 58                                       | .0269       | 94                                       | .0642       | 130                                      | .1015       | 166                                      | .1389       | 202                                      | .1764       |
| 59                                       | .0279       | 95                                       | .0652       | 131                                      | .1025       | 167                                      | .1400       | 203                                      | .1775       |
| 60                                       | .0290       | 96                                       | .0663       | 132                                      | .1036       | 168                                      | .1410       | 204                                      | .1785       |
| 61                                       | .0300       | 97                                       | .0673       | 133                                      | .1046       | 169                                      | .1420       | 205                                      | .1796       |
| 62                                       | .0311       | 98                                       | .0683       | 134                                      | .1057       | 170                                      | .1431       | 206                                      | .1806       |
| 63                                       | .0321       | 99                                       | .0694       | 135                                      | .1067       | 171                                      | .1441       | 207                                      | .1817       |
| 64                                       | .0331       | 100                                      | .0704       | 136                                      | .1077       | 172                                      | .1452       | 208                                      | .1827       |
| 65                                       | .0342       | 101                                      | .0714       | 137                                      | .1088       | 173                                      | .1462       | 209                                      | .1837       |
| 66                                       | .0352       | 102                                      | .0725       | 138                                      | .1098       | 174                                      | .1473       | 210                                      | .1848       |
| 67                                       | .0362       | 103                                      | .0735       | 139                                      | .1109       | 175                                      | .1483       | 211                                      | .1858       |
| 68                                       | .0372       | 104                                      | .0746       | 140                                      | .1119       | 176                                      | .1493       | 212                                      | .1869       |

XI.

TOTAL AVAILABLE ENERGY IN WATER AND STEAM.

| Pressure above a vacuum in pounds per square inch. | Same pressure as indicated by steam-gauge, allowing 14.7 pounds for atmospheric pressure. | Absolute pressure in atmospheres. | Number of British thermal units required for the evaporation of one pound of water, known as latent heat of evaporation, <i>H</i> . | Temperature in degrees Fahrenheit of the steam and of the water from which it is evaporated. | Temperature in degrees Centigrade of the steam and of the water from which it is evaporated. | Corresponding absolute temperature in degrees Fahrenheit. | Corresponding absolute temperature in degrees Centigrade. | Amount of energy contained in one pound of water which may be liberated by expansion or evaporation, 212° Fahr. | Corresponding amount of energy contained in the latent heat of evaporation. | Total amount of energy contained in one pound of steam at corresponding temperatures and pressures. |
|--|---|-----------------------------------|---|--|--|---|---|---|---|---|
| 20   | 5.3   | 1.36                              | 954.415   | 227.9  | 108.8  | 689.0   | 382.8   | 145.9   | 16872.9   | 17018.8   |
| 25   | 10.3  | 1.70                              | 945.885   | 249.0  | 115.5  | 701.2   | 389.5   | 439.7   | 20156.8   | 20596.5   |
| 30   | 15.3  | 2.04                              | 938.925   | 280.2  | 121.2  | 711.4   | 395.2   | 813.5   | 38921.0   | 39735.4   |
| 35   | 20.3  | 2.38                              | 932.132   | 259.1  | 126.1  | 720.3   | 400.1   | 1293.4  | 47054.0   | 48278.3   |
| 40   | 25.3  | 2.72                              | 926.472   | 267.1  | 130.1  | 728.3   | 404.6   | 1645.7  | 54111.7   | 55757.4   |
| 45   | 30.3  | 3.06                              | 921.334   | 274.2  | 134.5  | 735.4   | 408.5   | 2112.9  | 61158.7   | 62711.0   |
| 50   | 35.3  | 3.40                              | 916.631   | 280.8  | 138.2  | 742.0   | 412.2   | 2550.4  | 65013.8   | 68104.2   |
| 55   | 40.3  | 3.74                              | 912.296   | 286.8  | 141.5  | 748.0   | 415.5   | 2999.9  | 70428.7   | 73428.6   |
| 60   | 45.3  | 4.08                              | 908.2472  | 292.5  | 144.7  | 753.9   | 418.7   | 3449.2  | 74864.6   | 78333.8   |
| 65   | 50.3  | 4.42                              | 904.4621  | 297.7  | 147.6  | 758.9   | 421.6   | 3899.8  | 78850.5   | 82750.3   |
| 70   | 55.3  | 4.76                              | 900.8991  | 302.7  | 150.4  | 763.9   | 424.4   | 4361.1  | 82577.7   | 86938.8   |
| 75   | 60.3  | 5.10                              | 897.5269  | 307.3  | 152.9  | 768.5   | 426.9   | 4815.8  | 85923.6   | 90739.4   |
| 80   | 65.3  | 5.44                              | 894.3304  | 311.8  | 155.4  | 773.0   | 429.4   | 5266.5  | 89138.7   | 94345.2   |
| 85   | 70.3  | 5.78                              | 891.2862  | 316.0  | 157.7  | 777.2   | 431.7   | 5638.0  | 92073.3   | 97712.2   |
| 90   | 75.3  | 6.12                              | 888.3758  | 320.0  | 160.0  | 781.2   | 434.0   | 6058.1  | 94814.7   | 100872.8  |
| 95   | 80.3  | 6.46                              | 885.5887  | 323.8  | 162.1  | 785.0   | 436.1   | 6474.2  | 97447.2   | 103921.4  |
| 100  | 85.3  | 6.80                              | 882.9144  | 327.5  | 164.1  | 788.7   | 438.1   | 6885.2  | 99787.6   | 106972.8  |
| 105  | 90.3  | 7.14                              | 880.3429  | 331.1  | 166.1  | 792.3   | 440.1   | 7290.3  | 102163.3  | 109453.6  |
| 110  | 95.3  | 7.48                              | 877.8653  | 334.5  | 168.0  | 795.7   | 442.0   | 7680.0  | 104324.0  | 112023.3  |
| 115  | 100.3   | 7.82                              | 875.4721  | 337.8  | 169.8  | 799.0   | 443.8   | 8087.3  | 106421.9  | 114509.0  |
| 120  | 105.3   | 8.16                              | 873.1555  | 340.9  | 171.6  | 802.1   | 445.0   | 8485.1  | 108325.4  | 116808.5  |
| 125  | 110.3   | 8.50                              | 870.9115  | 344.0  | 173.3  | 805.2   | 447.3   | 8894.9  | 110219.9  | 119064.8  |
| 130  | 115.3   | 8.84                              | 868.7351  | 347.0  | 175.0  | 808.2   | 449.0   | 9252.6  | 112025.5  | 121278.2  |
| 135  | 120.3   | 9.18                              | 866.6223  | 349.9  | 176.6  | 811.1   | 450.6   | 9552.0  | 113745.7  | 123372.7  |
| 140  | 125.3   | 9.52                              | 864.5661  | 352.7  | 178.1  | 813.9   | 452.1   | 9922.6  | 115382.1  | 125374.7  |

TOTAL AVAILABLE ENERGY IN WATER AND STEAM—Continued.

| Pressure above a vacuum in pounds per square inch. | Same pressure as indicated by steam-gauge, allowing 14.7 pounds for atmospheric pressure. | Absolute pressure in atmospheres. | Number of British thermal units required for the evaporation of one pound of water, known as latent heat of evaporation, <i>H</i> . | Temperature in degrees Fahrenheit of the steam and of the water from which it is evaporated. | Temperature in degrees Centigrade of the steam and of the water from which it is evaporated. | Corresponding absolute temperature in degrees Fahrenheit. | Corresponding absolute temperature in degrees Centigrade. | Amount of energy contained in one pound of water which may be liberated by expansion to 212° Fahr. | Corresponding energy contained in the latent heat of evaporation. | Total amount of energy contained in one pound of steam at corresponding temperature and pressures. |
|--|---|-----------------------------------|---|--|--|---|---|--|---|--|
| 145  | 130.3   | 9.86                              | 862.5979  | 355.5  | 179.7  | 816.7   | 453.7   | 10361.0  | 117003.5  | 127364.5   |
| 150  | 135.3   | 10.20                             | 860.6213  | 358.1  | 181.1  | 819.3   | 455.1   | 10536.5  | 118477.2  | 129003.7   |
| 155  | 140.3   | 10.54                             | 858.7276  | 360.7  | 182.6  | 821.9   | 456.6   | 11085.9  | 119939.4  | 131095.3   |
| 160  | 145.3   | 10.88                             | 856.8740  | 363.2  | 184.0  | 824.4   | 458.0   | 11444.2  | 121323.6  | 132767.8   |
| 165  | 150.3   | 11.22                             | 855.0654  | 365.7  | 185.4  | 826.9   | 459.4   | 11823.4  | 122697.8  | 134521.2   |
| 170  | 155.3   | 11.56                             | 853.2942  | 368.1  | 186.7  | 829.3   | 460.7   | 12141.3  | 123995.5  | 136156.8   |
| 175  | 160.3   | 11.90                             | 851.5670  | 370.5  | 188.0  | 831.7   | 462.0   | 12508.7  | 125284.7  | 137793.4   |
| 180  | 165.3   | 12.24                             | 849.8658  | 372.8  | 189.3  | 834.0   | 463.3   | 12821.4  | 126499.1  | 139320.5   |
| 185  | 170.3   | 12.58                             | 848.2086  | 375.0  | 190.5  | 836.2   | 464.5   | 13182.0  | 127642.4  | 140824.4   |
| 190  | 175.3   | 12.92                             | 846.5844  | 377.2  | 191.7  | 838.4   | 465.7   | 13582.0  | 128778.8  | 142145.9   |
| 195  | 180.3   | 13.26                             | 844.9938  | 379.4  | 193.0  | 840.6   | 467.0   | 13844.1  | 129908.3  | 143752.4   |
| 200  | 185.3   | 13.60                             | 843.4326  | 381.5  | 194.1  | 842.7   | 468.1   | 14153.3  | 130967.4  | 145120.7   |
| 210  | 193.3   | 14.28                             | 840.3967  | 385.6  | 196.4  | 846.8   | 470.4   | 14830.8  | 133003.2  | 147834.0   |
| 220  | 203.3   | 14.60                             | 838.3864  | 389.8  | 198.7  | 851.0   | 472.7   | 15403.1  | 135003.3  | 151466.4   |
| 230  | 215.3   | 15.04                             | 833.9691  | 394.2  | 201.2  | 855.4   | 475.2   | 16180.3  | 137134.2  | 154814.7   |
| 240  | 225.3   | 15.32                             | 832.6419  | 397.9  | 203.3  | 859.1   | 477.3   | 16790.2  | 139094.3  | 158884.5   |
| 250  | 235.3   | 15.64                             | 830.3630  | 401.0  | 205.0  | 862.2   | 479.0   | 17314.4  | 140816.0  | 162580.2   |
| 300  | 285.3   | 18.02                             | 820.8592  | 447.6  | 242.0  | 898.8   | 516.0   | 22783.3  | 165892.7  | 175940.4   |
| 400  | 385.3   | 24.01                             | 780.8592  | 546.8  | 286.0  | 1008.0  | 560.0   | 48671.5  | 179212.0  | 202783.3   |
| 500  | 485.3   | 34.01                             | 720.4350  | 643.7  | 339.8  | 1104.9  | 613.8   | 75777.2  | 194221.3  | 269998.5   |
| 1000   | 1085.3  | 136.05                            | 643.9049  | 798.3  | 375.9  | 1169.5  | 649.7   | 161116.3   | 203555.5  | 289671.3   |
| 2000   | 2085.3  | 272.08                            | 590.8038  | 908.3  | 405.0  | 1223.9  | 679.9   | 184498.6   | 193501.7  | 303700.3   |
| 3000   | 3085.3  | 408.16                            | 544.6774  | 807.8  | 431.0  | 1269.0  | 705.1   | 130494.2   | 183305.9  | 313800.1   |
| 4000   | 4085.3  | 544.24                            | 505.7330  | 815.9  | 452.1  | 1307.1  | 726.1   | 144413.4   | 176056.9  | 321070.3   |
| 5000   | 5085.3  | 680.32                            | 471.6429  | 885.9  | 471.7  | 1342.4  | 745.7   | 157944.2   | 169333.3  | 327271.5   |
| 6000   | 6085.3  | 816.40                            | 439.9985  | 881.2  | 490.1  | 1375.5  | 764.1   | 170832.0   | 161392.6  | 332224.6   |
| 7000   | 7085.3  | 952.48                            | 409.4533  | 945.3  | 507.3  | 1406.4  | 781.5   | 183998.6   | 153998.0  | 337142.6   |
| 8000   | 8085.3  | 1088.56                           | 382.0347  | 914.2  | 521.8  | 1439.0  | 795.8   | 193787.0   | 145376.8  | 339164.2   |
| 9000   | 9085.3  | 1224.64                           | 355.2401  | 971.4  | 521.8  | 1439.0  | 795.8   | .....  | .....   | .....  |
| 10000  | 9995.3  | 1360.72                           | 305.3040  | 2163.4   | 1184.1   | 2624.6  | 1458.1  | .....  | .....   | .....  |



XII.  
FORMULAS RELATING TO PROPERTIES OF STEAM.

| QUANTITY.  | SYMBOL. | FORMULA.   |
|--|---------|--|
| Pounds per square inch.  | $P$     | $P = \frac{p}{144}, \log P = 6.1007 \frac{2731.62}{t} - \frac{396944}{t^3}$              |
| Pounds per square foot.  | $p$     | $p = P \times 144, \log p = 8.2591 - \frac{2731.62}{t} - \frac{396944}{t^3}$             |
| Inches of mercury, at 32° Fahr.  | $M$     | $M = P \times 2.03759$   |
| Feet of distilled water, at temperature of maximum density.                          | $F$     | $F = P \times 2.306768$  |
| Atmospheres.   | $A$     | $A = P \times 0.0680967$   |
| Above the atmosphere, in pounds per square inch.                                     | $G$     | $G = P - 14.685$   |
| Fahrenheit's scales.   | $t$     | $t = T - 461^{\circ}.2$  |
| Absolute scale, Fahrenheit degrees.  | $T$     | $T = 1 + \left( \sqrt[3]{\frac{8.2591 - \log p}{396944}} + 0.0000184 - 0.003441 \right)$ |
| Required to raise the temperature of the water from 32° to $t^{\circ}$ .             | $S$     | $S = t - 32 + 0.00000103(t - 39.1)^3$  |
| Required to change the water into steam. (Internal latent heat.)                     | $I$     | $I = L - E$  |
| Required to overcome the pressure of the surrounding medium. (External latent heat.) | $E$     | $E = p \times \frac{C - v}{772}$   |
| Latent heat of evaporation, under constant pressure, $P$ .                           | $L$     | $L = 1091.7 - 0.695(t - 32) - 0.00000103(t - 39.1)^3$                                    |
| Total heat of evaporation above 32°.   | $H$     | $H = 1091.7 + 0.305(t - 32)$   |
| Total heat of evaporation per pound of steam, above 32°, in units of evaporation.    | $U$     | $U = \frac{H}{966.1}$  |

Pressure.

Temperature.

Quantity of heat.





FORMULAS RELATING TO PROPERTIES OF STEAM—Continued.

| QUANTITY.   | SYMBOL. | FORMULA.  |
|---|---------|---|
| Foot-pounds of energy, in latent heat of evaporation, per cubic foot of steam.  | $l$     | $l = 2.3026 \times \rho \times \left( \frac{2731.62}{T} + \frac{793888}{T^2} \right)$   |
| Weight.   |         |   |
| Of a cubic foot of steam, in pounds.  | $W$     | $W = \frac{l}{772 \times L}$  |
| Of a cubic foot of distilled water, in pounds, at temperature $t$ .   | $w$     | $w = \frac{62.425}{v}$  |
| Volume.   |         |   |
| Of a pound of steam, in cubic feet.   | $C$     | $C = \frac{1}{W}$   |
| Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density.              | $V$     | $V = C \times 62.425$   |
| Ratio of volume of distilled water, at temperature $T$ , to volume of equal weight at temperature of maximum density. | $v$     | <p>For temperatures from <math>32^\circ</math> to <math>70^\circ</math><br/> <math>v = 1.00012 - 0.00003914(t - 32) + 0.000003822(t - 32)^2</math><br/> <math>- 0.0000006403(t - 32)^3</math><br/>           For temperatures above <math>70^\circ</math>,<br/> <math>v = 0.99781 + 0.0000617(t - 32) + 0.00000059(t - 32)^2</math></p> |

XIII.  
FACTORS OF EVAPORATION.

GAUGE PRESSURE IN POUNDS PER SQUARE INCH ABOVE THE ATMOSPHERE AND IN ATMOSPHERES.

Temperature of  
Feed-water in  
Degrees.

| F.  | C.    |       | 25    | 30    | 35    | 40    | 45    | 50    | 60    | 70    | 80    | 90    | 100   | 120   | 140   | 160   | 180 | 200 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|-----|
|     | 1.7   | 2.0   |       |       |       |       |       |       |       |       |       |       |       |       |       |       |     |     |
| 32  | 1.204 | 1.206 | 1.209 | 1.211 | 1.212 | 1.214 | 1.217 | 1.219 | 1.222 | 1.224 | 1.227 | 1.231 | 1.234 | 1.237 | 1.239 | 1.241 |     |     |
| 35  | .201  | .203  | .205  | .208  | .209  | .211  | .214  | .216  | .219  | .221  | .224  | .228  | .231  | .234  | .236  | .238  |     |     |
| 40  | .196  | .198  | .201  | .203  | .204  | .206  | .209  | .211  | .214  | .216  | .219  | .223  | .226  | .229  | .231  | .233  |     |     |
| 45  | .190  | .192  | .195  | .197  | .198  | .200  | .203  | .205  | .208  | .210  | .213  | .217  | .220  | .223  | .225  | .227  |     |     |
| 50  | .185  | .187  | .190  | .192  | .193  | .195  | .198  | .200  | .203  | .205  | .208  | .212  | .215  | .218  | .220  | .222  |     |     |
| 55  | .180  | .182  | .185  | .187  | .188  | .190  | .193  | .195  | .198  | .200  | .203  | .207  | .210  | .213  | .215  | .217  |     |     |
| 60  | .175  | .177  | .180  | .182  | .183  | .185  | .188  | .190  | .193  | .195  | .198  | .202  | .205  | .208  | .210  | .212  |     |     |
| 65  | .170  | .172  | .175  | .177  | .178  | .180  | .183  | .185  | .188  | .190  | .193  | .197  | .200  | .203  | .205  | .207  |     |     |
| 70  | .165  | .167  | .170  | .172  | .173  | .175  | .178  | .180  | .183  | .185  | .188  | .192  | .195  | .198  | .200  | .202  |     |     |
| 75  | .160  | .162  | .165  | .167  | .168  | .170  | .173  | .175  | .178  | .180  | .183  | .187  | .190  | .193  | .195  | .197  |     |     |
| 80  | .154  | .156  | .159  | .161  | .162  | .164  | .167  | .169  | .172  | .174  | .177  | .181  | .184  | .186  | .188  | .191  |     |     |
| 85  | .149  | .151  | .154  | .156  | .157  | .159  | .162  | .164  | .167  | .169  | .172  | .176  | .179  | .182  | .184  | .186  |     |     |
| 90  | .144  | .146  | .149  | .151  | .152  | .154  | .157  | .159  | .162  | .164  | .167  | .171  | .174  | .177  | .179  | .181  |     |     |
| 95  | .139  | .141  | .144  | .146  | .147  | .149  | .152  | .154  | .157  | .159  | .162  | .166  | .169  | .172  | .174  | .176  |     |     |
| 100 | .138  | .136  | .139  | .141  | .142  | .144  | .147  | .149  | .152  | .154  | .157  | .161  | .164  | .167  | .169  | .171  |     |     |
| 105 | .128  | .130  | .133  | .135  | .136  | .138  | .141  | .143  | .146  | .148  | .151  | .155  | .158  | .161  | .163  | .165  |     |     |
| 110 | .123  | .125  | .128  | .130  | .131  | .133  | .136  | .138  | .141  | .143  | .146  | .150  | .153  | .156  | .158  | .160  |     |     |
| 115 | .118  | .120  | .123  | .125  | .126  | .128  | .131  | .133  | .136  | .138  | .141  | .145  | .148  | .151  | .153  | .155  |     |     |
| 120 | .113  | .115  | .118  | .120  | .121  | .123  | .126  | .128  | .131  | .133  | .136  | .140  | .143  | .146  | .148  | .150  |     |     |
| 125 | .108  | .110  | .113  | .115  | .116  | .118  | .121  | .123  | .126  | .128  | .131  | .135  | .138  | .141  | .143  | .145  |     |     |
| 130 | .102  | .104  | .107  | .109  | .110  | .112  | .115  | .117  | .120  | .122  | .125  | .129  | .132  | .135  | .137  | .139  |     |     |
| 135 | .097  | .099  | .102  | .104  | .105  | .107  | .110  | .112  | .115  | .117  | .120  | .124  | .127  | .130  | .132  | .134  |     |     |
| 140 | .092  | .094  | .097  | .099  | .100  | .102  | .105  | .107  | .110  | .112  | .115  | .119  | .122  | .125  | .127  | .129  |     |     |
| 145 | .087  | .089  | .092  | .094  | .095  | .097  | .100  | .102  | .105  | .107  | .110  | .114  | .117  | .120  | .122  | .124  |     |     |
| 150 | .082  | .084  | .087  | .089  | .090  | .092  | .095  | .097  | .100  | .102  | .105  | .109  | .112  | .115  | .117  | .119  |     |     |
| 155 | .076  | .078  | .081  | .083  | .084  | .086  | .089  | .091  | .094  | .096  | .099  | .103  | .106  | .109  | .111  | .113  |     |     |
| 160 | .071  | .073  | .076  | .078  | .079  | .081  | .084  | .086  | .089  | .091  | .094  | .098  | .101  | .104  | .106  | .108  |     |     |
| 165 | .066  | .068  | .071  | .073  | .074  | .076  | .079  | .081  | .084  | .086  | .089  | .093  | .096  | .099  | .101  | .103  |     |     |
| 170 | .061  | .063  | .066  | .068  | .069  | .071  | .074  | .076  | .079  | .081  | .084  | .088  | .091  | .094  | .096  | .098  |     |     |
| 175 | .056  | .058  | .061  | .063  | .064  | .066  | .069  | .071  | .074  | .076  | .079  | .083  | .086  | .089  | .091  | .093  |     |     |
| 180 | .050  | .052  | .055  | .057  | .058  | .060  | .063  | .065  | .068  | .070  | .073  | .077  | .080  | .083  | .085  | .087  |     |     |
| 185 | .045  | .047  | .050  | .052  | .053  | .055  | .058  | .060  | .063  | .065  | .068  | .072  | .075  | .078  | .080  | .082  |     |     |
| 190 | .040  | .042  | .045  | .047  | .048  | .050  | .053  | .055  | .058  | .060  | .063  | .067  | .070  | .073  | .075  | .077  |     |     |
| 195 | .035  | .037  | .040  | .042  | .043  | .045  | .048  | .050  | .053  | .055  | .058  | .062  | .065  | .067  | .070  | .072  |     |     |
| 200 | .030  | .032  | .035  | .037  | .038  | .040  | .043  | .045  | .048  | .050  | .053  | .057  | .060  | .063  | .065  | .067  |     |     |
| 205 | .025  | .027  | .030  | .032  | .033  | .035  | .038  | .040  | .043  | .045  | .048  | .052  | .055  | .058  | .060  | .062  |     |     |
| 210 | .020  | .022  | .025  | .027  | .028  | .030  | .033  | .035  | .038  | .040  | .043  | .047  | .050  | .053  | .055  | .057  |     |     |

## XIV.

## COMPOSITION OF VARIOUS FUELS OF THE UNITED STATES.

|  | C.   | H.   | O.   | N.   | S.   | Mois-<br>ture. | Ash. | Spec.<br>Grav. |
|--|------|------|------|------|------|----------------|------|----------------|
| Pennsylvania Anthracite.....             | 78.6 | 2.5  | 1.7  | 0.8  | 0.4  | 1.2            | 14.8 | 1.45           |
| Rhode Island ".....                      | 85.8 | 10.5 |      | .... | 3.7  | ....           | .... | 1.85           |
| Massachusetts ".....                     | 92.0 | 6.0  |      | .... | 2.0  | ....           | .... | 1.78           |
| North Carolina ".....                    | 83.1 | 7.8  |      | .... | 9.1  | ....           | .... | ....           |
| Welsh ".....                             | 84.2 | 3.7  | 2.3  | 0.9  | 0.9  | 1.3            | 6.7  | 1.40           |
| Maryland Semi-bituminous.....            | 80.5 | 4.5  | 2.7  | 1.1  | 1.2  | 1.7            | 8.3  | 1.33           |
| Pennsylvania ".....                      | 75.8 | 20.2 |      | .... | .... | ....           | 4.0  | 1.32           |
| Indiana ".....                           | 59.4 | 38.8 |      | .... | .... | ....           | 1.8  | 1.30           |
| ".....                                   | 70.0 | 28.0 |      | .... | .... | ....           | 2.0  | 1.24           |
| ".....                                   | 52.0 | 39.0 |      | .... | .... | ....           | 9.0  | 1.27           |
| Illinois Bituminous.....                 | 62.6 | 35.5 |      | .... | .... | ....           | 1.9  | 1.30           |
| " (Block) Bituminous.....                | 58.2 | 37.1 |      | .... | .... | ....           | 4.7  | ....           |
| Illinois and Indiana (Cannel) Bituminous | 59.5 | 36.6 |      | .... | .... | ....           | 3.9  | 1.27           |
| Kentucky (Cannel) Bituminous.....        | 48.4 | 48.8 |      | .... | .... | ....           | 2.8  | 1.25           |
| Tennessee Bituminous.....                | 71.0 | 17.0 |      | .... | .... | ....           | 12.0 | 1.45           |
| ".....                                   | 41.5 | 56.5 |      | .... | .... | ....           | 2.5  | ....           |
| Alabama ".....                           | 54.0 | 42.6 |      | .... | 1.0  | 1.2            | 1.2  | ....           |
| Virginia ".....                          | 55.0 | 41.0 |      | .... | .... | ....           | 4.0  | ....           |
| ".....                                   | 74.0 | 18.6 |      | .... | .... | ....           | 7.4  | ....           |
| California and Oregon Lignite.....       | 50.1 | 3.9  | 13.7 | 0.9  | 1.5  | 16.7           | 13.2 | 1.32           |

| STATE.            | COAL.<br>KIND OF COAL. | Per Cent. of<br>Ash. | THEORETICAL VALUE. |                                      |
|-------------------|------------------------|----------------------|--------------------|--------------------------------------|
|                   |                        |                      | In Heat<br>Units.  | In Pounds<br>of Water<br>Evaporated. |
| Pennsylvania..... | Anthracite.....        | 3.49                 | 14,199             | 14.70                                |
| ".....            | ".....                 | 6.13                 | 13,535             | 14.01                                |
| ".....            | ".....                 | 2.90                 | 14,221             | 14.72                                |
| ".....            | Cannel.....            | 15.02                | 13,143             | 13.60                                |
| ".....            | Connellsville.....     | 6.50                 | 13,368             | 13.84                                |
| ".....            | Semi-bituminous.....   | 10.77                | 13,155             | 13.62                                |
| ".....            | Stone's Gas.....       | 5.00                 | 14,021             | 14.51                                |
| ".....            | Youghiogeny.....       | 5.60                 | 14,265             | 14.76                                |
| ".....            | Brown.....             | 9.50                 | 12,324             | 12.75                                |
| Kentucky.....     | Caking.....            | 2.75                 | 14,391             | 14.89                                |
| ".....            | Cannel.....            | 2.00                 | 15,198             | 16.76                                |
| ".....            | ".....                 | 14.80                | 13,360             | 13.84                                |
| ".....            | Lignite.....           | 7.00                 | 9,326              | 9.65                                 |
| Illinois.....     | Bureau County.....     | 5.20                 | 13,025             | 13.48                                |
| ".....            | Mercer County.....     | 5.60                 | 13,123             | 13.58                                |
| ".....            | Montauk.....           | 5.50                 | 12,659             | 13.10                                |
| Indiana.....      | Block.....             | 2.50                 | 13,588             | 14.38                                |
| ".....            | Caking.....            | 5.66                 | 14,146             | 14.64                                |
| ".....            | Cannel.....            | 6.00                 | 13,097             | 13.50                                |
| Maryland.....     | Cumberland.....        | 13.98                | 12,226             | 12.65                                |
| Arkansas.....     | Lignite.....           | 5.00                 | 9,215              | 9.54                                 |
| Colorado.....     | ".....                 | 9.25                 | 13,562             | 14.04                                |
| ".....            | ".....                 | 4.50                 | 13,866             | 14.35                                |
| Texas.....        | ".....                 | 4.50                 | 12,962             | 13.41                                |
| Washington.....   | ".....                 | 3.40                 | 11,551             | 11.96                                |
| Pennsylvania..... | Petroleum.....         | ....                 | 20,746             | 21.47                                |

## ANALYSES OF ASH.

|                              | Specific Grav. | Color of Ash. | Silica. | Alumina. | Oxide Iron. | Lime. | Magnesia. | Loss. | Acids S.&P. |
|------------------------------|----------------|---------------|---------|----------|-------------|-------|-----------|-------|-------------|
|                              |                | Reddish       |         |          |             |       |           |       |             |
| Pennsylvania Anthracite..... | 1.559          | Buff.         | 45.6    | 42.75    | 9.43        | 1.41  | 0.33      | 0.48  | ....        |
| "    Bituminous.....         | 1.372          | Gray.         | 76.0    | 21.00    | 2.60        | ....  | ..        | 0.40  | ....        |
| Welsh Anthracite.....        | 1.32           | ....          | 40.0    | 44.8     | ....        | 12.0  | trace     | ....  | 2.97        |
| Scotch Bituminous.....       | 1.26           | ....          | 37.6    | 52.0     | ....        | 3.7   | 1.1       | ....  | 5.02        |
| Lignite.....                 | 1.27           | ....          | 19.3    | 11.6     | 5.8         | 23.7  | 2.6       | ....  | 33.8        |

XV.  
HORSE-POWER PER POUND MEAN PRESSURE.

| Diameter of<br>Cylinder.<br>Inches. | SPEED OF PISTON IN FEET PER MINUTE. |        |        |        |        |        |        |        |        |        |        |
|-------------------------------------|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                                     | 100                                 | 240    | 300    | 350    | 400    | 450    | 500    | 550    | 600    | 650    | 750    |
| 4                                   | .038                                | .091   | .114   | .133   | .152   | .171   | .19    | .209   | .228   | .247   | .285   |
| 4½                                  | .048                                | .115   | .144   | .168   | .192   | .216   | .24    | .264   | .288   | .312   | .360   |
| 5                                   | .06                                 | .144   | .18    | .21    | .24    | .27    | .30    | .33    | .36    | .39    | .450   |
| 5½                                  | .072                                | .173   | .216   | .252   | .288   | .324   | .36    | .396   | .432   | .468   | .540   |
| 6                                   | .086                                | .205   | .256   | .299   | .342   | .385   | .428   | .471   | .513   | .555   | .641   |
| 6½                                  | .102                                | .245   | .307   | .391   | .409   | .464   | .512   | .563   | .614   | .668   | .800   |
| 7                                   | .116                                | .279   | .348   | .408   | .466   | .524   | .583   | .641   | .699   | .756   | .874   |
| 7½                                  | .134                                | .321   | .401   | .468   | .534   | .602   | .669   | .735   | .802   | .869   | 1.002  |
| 8                                   | .152                                | .365   | .456   | .532   | .608   | .685   | .761   | .837   | .912   | .989   | 1.121  |
| 8½                                  | .172                                | .413   | .516   | .602   | .688   | .774   | .86    | .946   | 1.032  | 1.118  | 1.290  |
| 9                                   | .192                                | .462   | .577   | .674   | .770   | .866   | .963   | 1.059  | 1.154  | 1.251  | 1.444  |
| 9½                                  | .215                                | .515   | .644   | .751   | .859   | .966   | 1.074  | 1.181  | 1.288  | 1.395  | 1.610  |
| 10                                  | .238                                | .571   | .714   | .833   | .952   | 1.071  | 1.190  | 1.309  | 1.428  | 1.547  | 1.785  |
| 10½                                 | .262                                | .63    | .787   | .919   | 1.050  | 1.181  | 1.313  | 1.444  | 1.575  | 1.706  | 1.969  |
| 11                                  | .288                                | .691   | .864   | 1.008  | 1.152  | 1.296  | 1.44   | 1.584  | 1.728  | 1.872  | 2.160  |
| 11½                                 | .314                                | .754   | .943   | 1.1    | 1.257  | 1.414  | 1.572  | 1.729  | 1.886  | 2.043  | 2.357  |
| 12                                  | .342                                | .820   | 1.025  | 1.195  | 1.366  | 1.540  | 1.708  | 1.880  | 2.050  | 2.222  | 2.564  |
| 12½                                 | .402                                | .964   | 1.206  | 1.407  | 1.608  | 1.809  | 2.01   | 2.211  | 2.412  | 2.613  | 3.015  |
| 14                                  | .466                                | 1.119  | 1.398  | 1.631  | 1.864  | 2.097  | 2.331  | 2.564  | 2.797  | 3.029  | 3.495  |
| 15                                  | .535                                | 1.285  | 1.606  | 1.873  | 2.131  | 2.409  | 2.677  | 2.945  | 3.212  | 3.479  | 4.004  |
| 16                                  | .609                                | 1.461  | 1.827  | 2.131  | 2.436  | 2.741  | 3.045  | 3.349  | 3.654  | 3.958  | 4.567  |
| 17                                  | .685                                | 1.643  | 2.054  | 2.396  | 2.739  | 3.081  | 3.424  | 3.766  | 4.108  | 4.450  | 5.135  |
| 18                                  | .771                                | 1.849  | 2.312  | 2.697  | 3.083  | 3.468  | 3.854  | 4.239  | 4.624  | 5.009  | 5.780  |
| 19                                  | .859                                | 2.061  | 2.577  | 3.006  | 3.436  | 3.865  | 4.295  | 4.724  | 5.154  | 5.583  | 6.442  |
| 20                                  | .952                                | 2.292  | 2.855  | 3.331  | 3.807  | 4.285  | 4.759  | 5.234  | 5.731  | 6.186  | 7.138  |
| 21                                  | 1.049                               | 2.518  | 3.148  | 3.672  | 4.197  | 4.722  | 5.247  | 5.771  | 6.296  | 6.820  | 7.869  |
| 22                                  | 1.152                               | 2.764  | 3.455  | 4.031  | 4.607  | 5.183  | 5.759  | 6.334  | 6.911  | 7.486  | 8.638  |
| 23                                  | 1.259                               | 3.021  | 3.776  | 4.405  | 5.035  | 5.664  | 6.294  | 6.923  | 7.552  | 8.181  | 9.44   |
| 24                                  | 1.370                               | 3.289  | 4.111  | 4.797  | 5.482  | 6.167  | 6.853  | 7.538  | 8.223  | 8.908  | 10.279 |
| 25                                  | 1.487                               | 3.569  | 4.461  | 5.195  | 5.948  | 6.692  | 7.436  | 8.179  | 8.923  | 9.566  | 11.053 |
| 26                                  | 1.609                               | 3.861  | 4.826  | 5.630  | 6.435  | 7.239  | 8.044  | 8.848  | 9.652  | 10.456 | 12.065 |
| 27                                  | 1.733                               | 4.159  | 5.199  | 6.066  | 6.932  | 7.799  | 8.666  | 9.532  | 10.399 | 11.265 | 12.998 |
| 28                                  | 1.865                               | 4.477  | 5.596  | 6.529  | 7.462  | 8.395  | 9.328  | 10.261 | 11.193 | 12.125 | 13.991 |
| 29                                  | 2.002                               | 4.805  | 6.006  | 7.007  | 8.008  | 9.009  | 10.01  | 11.011 | 12.012 | 13.013 | 15.015 |
| 30                                  | 2.142                               | 5.141  | 6.426  | 7.497  | 8.568  | 9.639  | 10.71  | 11.781 | 12.852 | 13.923 | 16.065 |
| 31                                  | 2.288                               | 5.486  | 6.865  | 8.001  | 9.144  | 10.287 | 11.43  | 12.573 | 13.716 | 14.866 | 17.145 |
| 32                                  | 2.436                               | 5.846  | 7.308  | 8.526  | 9.744  | 10.962 | 12.18  | 13.398 | 14.616 | 15.834 | 18.270 |
| 33                                  | 2.590                               | 6.216  | 7.770  | 9.065  | 10.360 | 11.655 | 12.959 | 14.245 | 15.54  | 16.835 | 19.425 |
| 34                                  | 2.746                               | 6.59   | 8.238  | 9.611  | 10.984 | 12.357 | 13.73  | 15.103 | 16.476 | 17.849 | 20.595 |
| 35                                  | 2.914                               | 6.993  | 8.742  | 10.199 | 11.656 | 13.113 | 14.57  | 16.027 | 17.484 | 18.941 | 21.855 |
| 36                                  | 3.084                               | 7.401  | 9.252  | 10.794 | 12.336 | 13.878 | 15.42  | 16.962 | 18.504 | 20.046 | 23.130 |
| 37                                  | 3.253                               | 7.819  | 9.774  | 11.403 | 13.032 | 14.861 | 16.29  | 17.919 | 19.548 | 21.177 | 24.433 |
| 38                                  | 3.436                               | 8.246  | 10.308 | 12.026 | 13.744 | 15.462 | 17.18  | 18.898 | 20.616 | 22.334 | 25.770 |
| 39                                  | 3.620                               | 8.648  | 10.86  | 12.67  | 14.48  | 16.29  | 18.1   | 19.91  | 21.62  | 23.53  | 27.150 |
| 40                                  | 3.808                               | 9.139  | 11.424 | 13.328 | 15.232 | 17.136 | 19.04  | 20.944 | 22.848 | 24.752 | 28.560 |
| 41                                  | 4.002                               | 9.604  | 12.006 | 14.007 | 16.008 | 18.009 | 20.00  | 22.011 | 24.012 | 26.013 | 30.015 |
| 42                                  | 4.198                               | 10.065 | 12.594 | 14.693 | 16.792 | 18.901 | 20.99  | 23.089 | 25.188 | 27.287 | 31.485 |
| 43                                  | 4.40                                | 10.56  | 13.20  | 15.4   | 17.6   | 19.8   | 22.00  | 24.2   | 26.4   | 28.6   | 33.00  |
| 44                                  | 4.606                               | 11.046 | 13.818 | 16.121 | 18.224 | 20.727 | 23.03  | 25.333 | 27.636 | 29.939 | 34.545 |
| 45                                  | 4.818                               | 11.563 | 14.454 | 16.863 | 19.072 | 21.681 | 24.09  | 26.399 | 28.908 | 31.317 | 36.135 |
| 46                                  | 5.043                               | 12.086 | 15.128 | 17.626 | 20.144 | 22.662 | 25.18  | 27.698 | 30.216 | 32.754 | 37.770 |
| 47                                  | 5.256                               | 12.614 | 15.768 | 18.396 | 21.024 | 23.652 | 26.28  | 28.908 | 31.536 | 34.164 | 39.420 |
| 48                                  | 5.482                               | 12.846 | 16.446 | 19.187 | 21.928 | 24.669 | 27.41  | 30.151 | 32.152 | 35.633 | 41.115 |
| 49                                  | 5.714                               | 12.913 | 17.142 | 19.999 | 22.856 | 25.713 | 28.57  | 31.427 | 34.284 | 37.141 | 42.855 |
| 50                                  | 5.950                               | 14.28  | 17.85  | 20.825 | 23.8   | 26.775 | 29.75  | 32.725 | 35.7   | 38.675 | 44.625 |
| 51                                  | 6.180                               | 14.832 | 18.54  | 21.665 | 24.76  | 27.855 | 30.95  | 34.045 | 37.08  | 40.205 | 46.425 |
| 52                                  | 6.432                               | 15.437 | 19.262 | 22.512 | 25.728 | 28.944 | 32.16  | 35.376 | 38.592 | 41.808 | 48.240 |
| 53                                  | 6.684                               | 16.041 | 20.056 | 23.394 | 26.736 | 30.078 | 33.42  | 36.762 | 40.104 | 43.446 | 50.130 |
| 54                                  | 6.940                               | 16.656 | 20.82  | 24.29  | 27.76  | 31.23  | 34.7   | 38.17  | 41.64  | 45.11  | 52.05  |
| 55                                  | 7.198                               | 17.275 | 21.594 | 25.193 | 28.792 | 32.391 | 35.99  | 39.589 | 43.188 | 46.787 | 53.985 |
| 56                                  | 7.462                               | 17.909 | 22.386 | 26.117 | 29.848 | 33.579 | 37.31  | 41.041 | 44.772 | 48.503 | 55.995 |
| 57                                  | 7.732                               | 18.557 | 23.196 | 27.062 | 30.928 | 34.794 | 38.66  | 42.526 | 46.392 | 50.258 | 57.99  |
| 58                                  | 8.006                               | 19.214 | 24.018 | 28.021 | 32.024 | 36.027 | 40.03  | 44.033 | 48.036 | 52.039 | 60.045 |
| 59                                  | 8.284                               | 19.902 | 24.852 | 28.964 | 33.136 | 37.278 | 41.42  | 45.562 | 49.704 | 53.846 | 62.13  |
| 60                                  | 8.566                               | 20.558 | 25.698 | 29.981 | 34.264 | 38.547 | 42.83  | 47.113 | 51.396 | 55.679 | 64.245 |



XVI.  
REAL RATIOS OF EXPANSION

| Per cent of Clearance. | POINTS OF CUT-OFF. |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|------------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                        | .10                | .125  | .20   | .25   | .80   | .883  | .875  | .40   | .50   | .60   | .625  | .70   | .75   | .80   | .875  | .90   |
| .01                    | 9.111              | 7.481 | 4.809 | 3.884 | 3.258 | 2.944 | 2.623 | 2.463 | 1.983 | 1.655 | 1.590 | 1.422 | 1.328 | 1.246 | 1.141 | 1.109 |
| .0125                  | 9                  | 7.363 | 4.764 | 3.875 | 3.24  | 2.930 | 2.612 | 2.454 | 1.975 | 1.653 | 1.588 | 1.421 | 1.327 | 1.246 | 1.140 | 1.109 |
| .0150                  | 8.826              | 7.25  | 4.720 | 3.830 | 3.222 | 2.916 | 2.602 | 2.445 | 1.970 | 1.650 | 1.585 | 1.419 | 1.326 | 1.245 | 1.140 | 1.109 |
| .0175                  | 8.659              | 7.133 | 4.677 | 3.803 | 3.204 | 2.902 | 2.592 | 2.436 | 1.966 | 1.647 | 1.583 | 1.418 | 1.325 | 1.244 | 1.140 | 1.108 |
| .02                    | 8.5                | 7.034 | 4.635 | 3.777 | 3.187 | 2.889 | 2.582 | 2.428 | 1.961 | 1.645 | 1.581 | 1.416 | 1.325 | 1.243 | 1.138 | 1.108 |
| .0225                  | 8.346              | 6.932 | 4.595 | 3.752 | 3.170 | 2.876 | 2.574 | 2.420 | 1.956 | 1.642 | 1.579 | 1.415 | 1.324 | 1.243 | 1.138 | 1.108 |
| .0250                  | 8.2                | 6.833 | 4.555 | 3.727 | 3.153 | 2.863 | 2.562 | 2.411 | 1.952 | 1.640 | 1.576 | 1.413 | 1.322 | 1.242 | 1.138 | 1.108 |
| .0275                  | 8.088              | 6.738 | 4.516 | 3.702 | 3.137 | 2.850 | 2.552 | 2.403 | 1.947 | 1.637 | 1.574 | 1.412 | 1.321 | 1.241 | 1.138 | 1.107 |
| .03                    | 7.933              | 6.645 | 4.477 | 3.678 | 3.121 | 2.837 | 2.543 | 2.395 | 1.943 | 1.634 | 1.572 | 1.410 | 1.320 | 1.240 | 1.138 | 1.107 |
| .0325                  | 7.792              | 6.555 | 4.440 | 3.654 | 3.105 | 2.824 | 2.533 | 2.387 | 1.938 | 1.632 | 1.570 | 1.409 | 1.319 | 1.240 | 1.138 | 1.107 |
| .0350                  | 7.666              | 6.468 | 4.404 | 3.631 | 3.089 | 2.812 | 2.524 | 2.379 | 1.934 | 1.629 | 1.568 | 1.408 | 1.318 | 1.239 | 1.137 | 1.106 |
| .0375                  | 7.545              | 6.390 | 4.368 | 3.608 | 3.074 | 2.800 | 2.515 | 2.371 | 1.930 | 1.627 | 1.566 | 1.406 | 1.317 | 1.238 | 1.136 | 1.106 |
| .04                    | 7.428              | 6.303 | 4.333 | 3.58  | 3.058 | 2.788 | 2.506 | 2.363 | 1.925 | 1.625 | 1.563 | 1.405 | 1.316 | 1.238 | 1.136 | 1.106 |
| .0425                  | 7.315              | 6.229 | 4.298 | 3.564 | 3.043 | 2.776 | 2.497 | 2.355 | 1.921 | 1.622 | 1.561 | 1.404 | 1.315 | 1.237 | 1.136 | 1.106 |
| .0450                  | 7.206              | 6.147 | 4.256 | 3.542 | 3.028 | 2.764 | 2.488 | 2.348 | 1.917 | 1.620 | 1.560 | 1.402 | 1.314 | 1.236 | 1.135 | 1.105 |
| .0475                  | 7.102              | 6.082 | 4.232 | 3.521 | 3.014 | 2.752 | 2.479 | 2.340 | 1.913 | 1.617 | 1.557 | 1.401 | 1.313 | 1.235 | 1.135 | 1.105 |
| .05                    | 7                  | 6     | 4.2   | 3.5   | 3     | 2.741 | 2.470 | 2.333 | 1.907 | 1.615 | 1.555 | 1.400 | 1.312 | 1.235 | 1.135 | 1.105 |
| .0525                  | 6.901              | 5.985 | 4.168 | 3.478 | 2.986 | 2.730 | 2.461 | 2.325 | 1.904 | 1.613 | 1.553 | 1.398 | 1.311 | 1.234 | 1.134 | 1.104 |
| .0550                  | 6.806              | 5.891 | 4.130 | 3.459 | 2.971 | 2.719 | 2.453 | 2.318 | 1.900 | 1.610 | 1.551 | 1.397 | 1.310 | 1.233 | 1.134 | 1.104 |
| .0575                  | 6.714              | 5.794 | 4.106 | 3.439 | 2.957 | 2.708 | 2.445 | 2.311 | 1.896 | 1.608 | 1.549 | 1.396 | 1.309 | 1.233 | 1.134 | 1.104 |
| .06                    | 6.625              | 5.729 | 4.076 | 3.418 | 2.944 | 2.697 | 2.436 | 2.304 | 1.892 | 1.606 | 1.547 | 1.394 | 1.308 | 1.232 | 1.133 | 1.104 |
| .0625                  | 6.538              | 5.666 | 4.047 | 3.407 | 2.931 | 2.686 | 2.428 | 2.297 | 1.888 | 1.603 | 1.545 | 1.393 | 1.307 | 1.231 | 1.133 | 1.103 |
| .0650                  | 6.454              | 5.605 | 4.024 | 3.386 | 2.917 | 2.675 | 2.420 | 2.290 | 1.884 | 1.601 | 1.543 | 1.392 | 1.306 | 1.231 | 1.132 | 1.103 |
| .0675                  | 6.373              | 5.545 | 3.999 | 3.362 | 2.904 | 2.665 | 2.412 | 2.283 | 1.881 | 1.599 | 1.541 | 1.390 | 1.305 | 1.230 | 1.132 | 1.103 |
| .07                    | 6.294              | 5.482 | 3.963 | 3.342 | 2.892 | 2.655 | 2.404 | 2.276 | 1.877 | 1.597 | 1.539 | 1.389 | 1.304 | 1.229 | 1.132 | 1.103 |













XIX.

WATER-COMPUTATION TABLE.

| T. P. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        |
|-------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 3     | 117.300  | 121.015  | 124.717  | 128.406  | 132.083  | 135.748  | 139.399  | 143.075  | 146.665  | 150.279  |
| 4     | 153.880  | 157.514  | 161.137  | 164.750  | 168.353  | 171.945  | 175.527  | 179.098  | 182.659  | 186.210  |
| 5     | 189.750  | 193.336  | 196.914  | 200.483  | 204.044  | 207.598  | 211.142  | 214.679  | 218.208  | 221.728  |
| 6     | 225.240  | 228.799  | 232.341  | 235.897  | 239.437  | 242.970  | 246.497  | 250.017  | 253.531  | 257.039  |
| 7     | 260.540  | 264.056  | 267.566  | 271.071  | 274.570  | 278.063  | 281.550  | 285.031  | 288.506  | 291.976  |
| 8     | 295.440  | 298.922  | 302.400  | 305.872  | 309.338  | 312.800  | 316.256  | 319.708  | 323.154  | 326.594  |
| 9     | 330.030  | 333.488  | 336.941  | 340.389  | 343.833  | 347.273  | 350.707  | 354.137  | 357.563  | 360.984  |
| 10    | 364.000  | 367.842  | 371.280  | 374.714  | 378.144  | 381.570  | 384.992  | 388.410  | 391.824  | 395.234  |
| 11    | 398.640  | 402.064  | 405.485  | 408.902  | 412.315  | 415.725  | 419.131  | 422.534  | 425.933  | 429.328  |
| 12    | 432.720  | 436.120  | 439.517  | 442.911  | 446.301  | 449.688  | 453.071  | 456.451  | 459.828  | 463.200  |
| 13    | 466.570  | 469.950  | 473.326  | 476.699  | 480.068  | 483.435  | 486.798  | 490.159  | 493.516  | 496.869  |
| 14    | 500.220  | 503.596  | 506.968  | 510.338  | 513.706  | 517.070  | 520.432  | 523.790  | 527.146  | 530.500  |
| 15    | 533.850  | 537.213  | 540.573  | 543.930  | 547.285  | 550.638  | 553.987  | 557.334  | 560.679  | 564.011  |
| 16    | 567.360  | 570.713  | 574.063  | 577.411  | 580.757  | 584.100  | 587.441  | 590.780  | 594.115  | 597.449  |
| 17    | 600.780  | 604.109  | 607.435  | 610.759  | 614.081  | 617.400  | 620.717  | 624.031  | 627.343  | 630.653  |
| 18    | 633.960  | 637.265  | 640.567  | 643.867  | 647.165  | 650.460  | 653.753  | 657.043  | 660.331  | 663.617  |
| 19    | 666.900  | 670.200  | 673.498  | 676.793  | 680.086  | 683.378  | 686.666  | 689.953  | 693.238  | 696.520  |
| 20    | 699.800  | 703.098  | 706.394  | 709.688  | 712.980  | 716.270  | 719.558  | 722.844  | 726.128  | 729.410  |
| 21    | 732.690  | 735.968  | 739.244  | 742.518  | 745.790  | 749.060  | 752.328  | 755.594  | 758.858  | 762.120  |
| 22    | 765.380  | 768.660  | 771.938  | 775.215  | 778.490  | 781.763  | 785.034  | 788.303  | 791.570  | 794.836  |
| 23    | 798.100  | 801.362  | 804.622  | 807.881  | 811.138  | 814.393  | 817.646  | 820.897  | 824.146  | 827.394  |
| 24    | 830.640  | 833.908  | 837.175  | 840.440  | 843.703  | 846.965  | 850.225  | 853.484  | 856.741  | 859.996  |
| 25    | 863.250  | 866.502  | 869.753  | 873.002  | 876.249  | 879.495  | 882.739  | 885.982  | 889.223  | 892.462  |
| 26    | 895.700  | 898.936  | 902.171  | 905.404  | 908.635  | 911.865  | 915.093  | 918.320  | 921.545  | 924.768  |
| 27    | 927.990  | 931.210  | 934.429  | 937.646  | 940.831  | 944.075  | 947.287  | 950.498  | 953.707  | 956.914  |
| 28    | 960.120  | 963.352  | 966.583  | 969.813  | 973.041  | 976.268  | 979.493  | 982.717  | 985.939  | 989.160  |
| 29    | 992.380  | 995.598  | 998.815  | 1002.031 | 1005.245 | 1008.458 | 1011.669 | 1014.879 | 1018.087 | 1021.294 |
| 30    | 1024.500 | 1027.704 | 1030.907 | 1034.109 | 1037.309 | 1040.508 | 1043.705 | 1046.901 | 1050.095 | 1053.288 |
| 31    | 1056.480 | 1059.670 | 1062.859 | 1066.047 | 1069.233 | 1072.418 | 1075.601 | 1078.783 | 1081.963 | 1085.142 |

## XIX.—(Continued.)

## WATER-COMPUTATION TABLE—Continued.

| T. P. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        |
|-------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 32    | 1088.320 | 1091.528 | 1094.736 | 1097.942 | 1101.146 | 1104.350 | 1107.552 | 1110.754 | 1113.954 | 1117.152 |
| 33    | 1120.350 | 1123.546 | 1126.742 | 1129.936 | 1133.128 | 1136.420 | 1139.510 | 1142.700 | 1145.888 | 1149.074 |
| 34    | 1152.200 | 1155.444 | 1158.628 | 1161.810 | 1164.990 | 1168.170 | 1171.348 | 1174.526 | 1177.702 | 1180.876 |
| 35    | 1184.050 | 1187.222 | 1190.394 | 1193.564 | 1196.732 | 1199.900 | 1203.066 | 1206.232 | 1209.398 | 1212.558 |
| 36    | 1215.720 | 1218.917 | 1222.112 | 1225.307 | 1228.500 | 1231.693 | 1234.884 | 1238.075 | 1241.264 | 1244.453 |
| 37    | 1247.040 | 1250.227 | 1253.412 | 1256.597 | 1260.380 | 1263.563 | 1266.744 | 1269.925 | 1273.104 | 1276.283 |
| 38    | 1279.460 | 1282.637 | 1285.812 | 1288.987 | 1292.160 | 1295.333 | 1298.504 | 1301.675 | 1304.844 | 1308.013 |
| 39    | 1311.180 | 1314.347 | 1317.512 | 1320.677 | 1323.840 | 1327.003 | 1330.164 | 1333.325 | 1336.484 | 1339.643 |
| 40    | 1342.800 | 1345.957 | 1349.112 | 1352.267 | 1355.420 | 1358.573 | 1371.724 | 1364.875 | 1368.024 | 1371.173 |
| 41    | 1374.320 | 1377.467 | 1380.612 | 1383.757 | 1386.900 | 1390.043 | 1393.184 | 1396.325 | 1399.464 | 1402.603 |
| 42    | 1405.740 | 1408.877 | 1412.012 | 1415.147 | 1418.280 | 1421.413 | 1424.544 | 1427.675 | 1430.804 | 1433.933 |
| 43    | 1437.060 | 1440.230 | 1443.398 | 1446.566 | 1449.734 | 1452.900 | 1456.066 | 1459.230 | 1462.394 | 1465.558 |
| 44    | 1468.720 | 1471.882 | 1475.042 | 1478.202 | 1481.362 | 1484.520 | 1487.678 | 1490.834 | 1493.990 | 1497.146 |
| 45    | 1500.300 | 1503.454 | 1506.606 | 1509.758 | 1512.910 | 1516.060 | 1519.210 | 1522.359 | 1525.506 | 1528.654 |
| 46    | 1531.800 | 1534.946 | 1538.090 | 1541.234 | 1544.378 | 1547.520 | 1550.662 | 1553.802 | 1556.942 | 1560.082 |
| 47    | 1563.220 | 1566.358 | 1569.494 | 1572.630 | 1575.766 | 1578.900 | 1582.034 | 1585.166 | 1588.298 | 1591.430 |
| 48    | 1594.560 | 1597.690 | 1600.818 | 1603.946 | 1607.074 | 1610.200 | 1613.326 | 1616.450 | 1619.574 | 1622.698 |
| 49    | 1625.820 | 1628.942 | 1632.062 | 1635.182 | 1638.302 | 1641.420 | 1644.538 | 1647.654 | 1650.770 | 1653.886 |
| 50    | 1657.000 | 1660.114 | 1663.226 | 1666.338 | 1669.450 | 1672.560 | 1675.670 | 1678.778 | 1681.886 | 1684.994 |
| 51    | 1688.100 | 1691.206 | 1694.310 | 1697.414 | 1700.518 | 1703.620 | 1706.722 | 1709.822 | 1712.922 | 1716.022 |
| 52    | 1719.120 | 1722.218 | 1725.314 | 1728.410 | 1731.506 | 1734.600 | 1737.604 | 1740.786 | 1743.878 | 1746.970 |
| 53    | 1750.060 | 1753.150 | 1756.238 | 1759.327 | 1762.414 | 1765.500 | 1768.586 | 1771.670 | 1774.754 | 1777.838 |
| 54    | 1780.920 | 1784.002 | 1787.082 | 1790.162 | 1793.242 | 1796.320 | 1799.398 | 1802.474 | 1805.556 | 1808.626 |
| 55    | 1811.700 | 1814.829 | 1817.957 | 1821.084 | 1824.212 | 1827.338 | 1830.463 | 1833.588 | 1836.713 | 1839.837 |
| 56    | 1842.900 | 1846.083 | 1849.205 | 1852.326 | 1855.447 | 1858.568 | 1861.687 | 1864.806 | 1867.925 | 1871.043 |
| 57    | 1874.160 | 1877.277 | 1880.393 | 1883.508 | 1886.623 | 1889.738 | 1892.851 | 1895.964 | 1899.077 | 1902.189 |
| 58    | 1905.300 | 1908.411 | 1911.521 | 1914.630 | 1917.739 | 1920.848 | 1923.955 | 1927.062 | 1930.169 | 1933.275 |
| 59    | 1936.380 | 1939.485 | 1942.589 | 1945.692 | 1948.795 | 1951.898 | 1954.999 | 1958.100 | 1961.201 | 1964.301 |
| 60    | 1967.400 | 1970.499 | 1973.597 | 1976.694 | 1979.791 | 1982.888 | 1985.983 | 1989.078 | 1992.173 | 1995.267 |



XX.

HIRN'S ANALYSIS.

DATA AND RESULTS.

|   |                                      |                    |
|---|--------------------------------------|--------------------|
| Test of Steam-engine made by.....         | at.....                              |                    |
| Kind of engine.....                       | Diam. cylinder.....                  | Length stroke..... |
| Diam. piston-rod.....                     | Vol. cylinder, crank end.....        | Vol. head end..... |
| Vol. clearance, cu. ft., head.....        | Clearance in per cent of stroke..... |                    |
| “ “ “ crank.....                          | “ “ “ .....                          | “ “ “ .....        |
| Boiler-pressure by gauge.....             | Barometer.....                       |                    |
| Boiler-pressure absolute.....             | Boiling temp., atmos. pressure.....  |                    |
| Revolutions per hour.....                 | Steam used during run, lbs.....      |                    |
| Quality of steam in steam-pipe.....       | Quality of steam in steam-chest..... |                    |
| Quality of steam in compression.....      | Quality of steam in exhaust.....     |                    |
| Weight of condensed steam per hour.....   |                                      |                    |
| Pounds of wet steam per stroke.....       | Head.....                            | Crank.....         |
| Temperatures condensed steam.....         |                                      |                    |
| Temperatures condensing water, cold.....  | Hot.....                             |                    |
| Pounds of condensing water, per hour..... | Per stroke.....                      |                    |

SYMBOLS.

To denote different portions of the stroke, the following subscripts are used :

Admission (*a*); expansion (*b*); exhaust (*c*); compression (*d*).

To denote different events of the stroke, the following sub-numbers are used :

Cut-off (1); release (2); compression, beginning of (3); admission, beginning of (4); in exhaust (5).

Quality of steam denoted by *X*.

|   |                                |
|---|--------------------------------|
| Cut-off, crank end per cent of stroke .....   | Release, crank end.....        |
| Cut-off, head end per cent of stroke .....    | Release, head end.....         |
| Compression, crank end per cent of stroke.... | Lbs. steam per I. H. P.....    |
| Compression, head end per cent of stroke....  | Lbs. steam per brake H. P..... |
| I. H. P.....                                  | Brake horse-power.....         |

XX.—(Continued.)  
DATA AND RESULTS  
PER 100 STROKES.

Engine.

Date

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| QUANTITIES.                              | SYMBOL. | FORMULA.  | RESULTS |        |
|--|---------|---|---------|--------|
|  |         |   | Head.   | Crank. |
| Weight steam per 100 strokes, lbs.....   | $M$     |   |         |        |
| Weight of steam in clearance, lbs.....   | $M_0$   | $V_0$ (Wt. per cu. ft.)<br>$X_0$                      |         |        |
| Weight of steam, total .....             | $M+M_0$ |   |         |        |
| Condensing water, lbs.....               | $G$     |   |         |        |
| Heat given to condensing water, B.T.U.   | $K$     | $G(S_k - S_l)$ .....                                  |         |        |
| Heat supplied engine, B.T.U. ....        | $Q$     | $M(XL + S)$ .....                                     |         |        |
| Heat retained by compression, B.T.U. .   | $Q_0$   | $M_0 S_0 + \frac{V_0 I_0}{C_0}$                       |         |        |
| External heat steam at cut-off, B.T.U. . | $H_1$   | $(M + M_0) S_1$ .....                                 |         |        |
| Internal heat steam at cut-off, B.T.U. . | $H_1'$  | $(V_0 + V_1) \frac{I_1}{C_1}$                         |         |        |
| Cylinder loss during admission, B.T.U.   | $Q_a$   | $Q + Q_0 - H_1 - H_1' - 778 W_a$ .....                |         |        |
| Loss sensible heat during expansion .... | $H_2$   | $(M + M_0)(S_1 - S_2)$ .....                          |         |        |
| Internal heat after expansion .....      | $H_2'$  | $(V_0 + V_2) \frac{I_2}{C_2}$                         |         |        |
| Cylinder loss during expansion, B.T.U.   | $Q_b$   | $H_2 + H_1' - H_2' - 778 W_b$ .....                   |         |        |
| Sensible heat at exhaust .....           | $H_0$   | $(M + M_0) S_2$ .....                                 |         |        |
| External heat at compression .....       | $H_3$   | $M_0 S_3$ .....                                       |         |        |
| Internal heat at compression .....       | $H_3$   | $(V_0 + V_3) \frac{I_3}{C_3}$                         |         |        |
| Heat delivered from condenser .....      | $H_0$   | $MS_3$ .....  |         |        |
| Heat carried off in exhaust .....        | $H_4$   | $M(XL_3 + S_3)$ (per calorimeter) .....               |         |        |
| Cylinder loss, exhaust, B.T.U. ....      | $Q_c$   | $H_0 + H_2' - H_3' - K - H_3 - H_0 - \frac{W_c}{778}$ |         |        |
| “ “ “ “ ..                               | $Q_c$   | $H_0 + H_2' - H_3' - H_3 - H_4 - \frac{W_c}{778}$     |         |        |
| Sensible heat, gain during compression.  | $H_3$   | $M_0(S_3 - S_0)$ .....                                |         |        |
| Internal heat at admission .....         | $H'$    | $V_0 \frac{I_0}{C_0}$                                 |         |        |
| Cylinder loss during compression, B.T.U. | $Q_d$   | $H_0' + H_3' - H' - \frac{W_d}{778}$                  |         |        |
| Heat admitted .....                      | $Q$     |   |         |        |
| Heat discharged and external work. . . . | $B$     | $H_0 + K + \text{total } W + 778$ .....               |         |        |
| Loss.....                                | $D$     | $Q - B$ .....   |         |        |
| Loss.....                                | $D'$    | $Q_a + Q_b + Q_c + Q_d$ .....                         |         |        |



XXI.

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

| Symbol.   | Formula.                              | POINT OF CUT-OFF. |       |        |        |        |        |        |        | Number for Reference. |    |
|---|---------------------------------------|-------------------|-------|--------|--------|--------|--------|--------|--------|-----------------------|----|
|   |                                       | Full Stroke.      | 3/4   | 2/3    | 1/2    | 1/4    | 1/6    | 1/8    | 1/10   |                       |    |
| Effective horse-power to be developed.....        | Assumed.                              | 150               | 150   | 150    | 150    | 150    | 150    | 150    | 150    | 150                   | 1  |
| Absolute initial pressure of steam, { .....       | Assumed.                              | 100               | 100   | 100    | 100    | 100    | 100    | 100    | 100    | 100                   | 2  |
| Back-pressure, pounds per square inch. ....       | Assumed.                              | 17.5              | 17.5  | 17.5   | 17.5   | 17.5   | 17.5   | 17.5   | 17.5   | 17.5                  | 3  |
| Apparent cut-off. ....                            | Assumed.                              | 1                 | .75   | .5     | .33    | .25    | .17    | .125   | .083   |                       | 4  |
| Absolute pressure at point of cut-off, { .....    | Assumed.                              | 90                | 92.5  | 95     | 96.5   | 97.5   | 98     | 98.5   | 99     | 99.5                  | 5  |
| Clearance at each end, in equiva- { Piston, ..... | Assumed.                              | .3125             | .3125 | .3125  | .3125  | .3125  | .3125  | .3125  | .3125  | .3125                 | 6  |
| lent length of cylinder, inches. { Port, .....    | Assumed.                              | .625              | .625  | .625   | .625   | .625   | .625   | .625   | .625   | .625                  | 7  |
| { Total, .....                                    | (P) + (p)                             | .9375             | 1.    | 1.0625 | 1.125  | 1.1875 | 1.25   | 1.3125 | 1.375  | 1.4375                | 8  |
| Piston-speed, feet per minute. ....               | Assumed.                              | 450               | 450   | 450    | 450    | 450    | 450    | 450    | 450    | 450                   | 9  |
| Mean absolute pressure up to cut-off, { .....     | $\frac{P+C}{2}$                       | 95                | 96.75 | 97.5   | 98.25  | 98.75  | 99     | 99.25  | 99.5   | 99.5                  | 10 |
| pounds per square inch. ....                      | Assumed.                              | 1                 | 1.33  | 2      | 3      | 4      | 6      | 8      | 12     | 12                    | 11 |
| Apparent ratio of expansion. ....                 | From tables.                          | .....             | .2877 | .6931  | 1.0986 | 1.3863 | 1.7918 | 2.0794 | 2.4849 |                       | 12 |
| Hyperbolic logarithm of apparent { .....          | $m + C \times \text{hyp log } r - b.$ |                   |       |        |        |        |        |        |        |                       |    |
| ratio of expansion. ....                          | $\frac{R}{T \times V}$                |                   |       |        |        |        |        |        |        |                       |    |
| Mean effective trial-pressure, { .....            | $\frac{33,000}{E}$                    | 77.5              | 75    | 64.2   | 50.6   | 41     | 28.3   | 20.5   | 11.3   |                       | 13 |
| pounds per square inch. ....                      | $\frac{1}{h}$                         | 1.057             | 1.023 | .739   | .690   | .562   | .386   | .280   | .154   |                       | 14 |
| Effective horse-power for trial-pressure, { ..... | $\sqrt{\frac{a}{2 \times d}}$         |                   |       |        |        |        |        |        |        |                       |    |
| each square inch of piston area. ....             | $\frac{.7854}{f \times s}$            | 141.9             | 142.7 | 203    | 217.4  | 267    | 388.6  | 536    | 974    |                       | 15 |
| Trial cross-section of cylinder, { .....          |                                       |                   |       |        |        |        |        |        |        |                       |    |
| square inches. ....                               |                                       |                   |       |        |        |        |        |        |        |                       |    |
| Trial diameter of cylinder, inches, { .....       |                                       |                   |       |        |        |        |        |        |        |                       |    |
| to nearest quarter-inch. ....                     |                                       | 13.5              | 13.5  | 16     | 16.5   | 18.5   | 22.25  | 26.25  | 35.25  |                       | 16 |
| Trial stroke of piston, inches. ....              |                                       | 27                | 27    | 32     | 33     | 37     | 45     | 52.5   | 70.5   |                       | 17 |
| Fraction of clearance. ....                       |                                       | .0347             | .037  | .0332  | .0341  | .0321  | .0292  | .0262  | .0239  |                       | 18 |

XXI.—(Continued.)

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

|   | Symbol.                       | Formula.                                      | POINT OF CUT-OFF. |       |       |        |        |        |        |        |       |       | Reference Number for |       |       |    |
|---|-------------------------------|---|-------------------|-------|-------|--------|--------|--------|--------|--------|-------|-------|----------------------|-------|-------|----|
|   |                               |   | Full Stroke.      | 3/4   | 2/3   | 1/2    | 1/3    | 1/4    | 1/5    | 1/6    | 1/8   | 1/10  |                      |       |       |    |
| Per cent of clearance to nearest quarter per cent.  | <i>c</i>                      | Assumed from <i>F</i> .                       | 3 1/2             | 3 1/2 | 3 1/2 | 3 1/2  | 3 1/2  | 3 1/2  | 3 1/2  | 3 1/2  | 3 1/2 | 3 1/2 | 3 1/2                | 3 1/2 | 3 1/2 | 19 |
| Real ratio of expansion.  | <i>R</i>                      | $\frac{1+c/100}{1/r+c/100}$                   | 1                 | 1.318 | 1.935 | 2.913  | 3.655  | 5.228  | 6.833  | 9.464  | 20    |       |                      |       |       |    |
| Hyperbolic logarithm of real ratio of expansion.  | $\frac{\text{hyp log } R}{R}$ | From tables.                                  | .....             | .2761 | .6601 | 1.0343 | 1.2961 | 1.6540 | 1.9218 | 2.2475 | 21    |       |                      |       |       |    |
| Mean pressure for stroke plus clearance, corrected for back-pressure, pounds per square inch.   | <i>M</i>                      | $\frac{m+C \times \text{hyp log } R}{R} - b$  | 77.5              | 75.4  | 65.3  | 52.9   | 44.7   | 32.4   | 24.7   | 16.8   | 22    |       |                      |       |       |    |
| Mean pressure corrected for back-pressure and clearance, pounds per square inch.  | <i>n</i>                      | $M - \frac{c}{100} \times (P - M)$            | 76.7              | 74.5  | 64.1  | 51.3   | 42.9   | 30.4   | 22.8   | 14.7   | 23    |       |                      |       |       |    |
| Ratio of compression.<br>{ When final cushion-pressure is less than initial pressure.<br>{ To make final cushion-pressure and initial pressure equal. | <i>l</i>                      | Assumed.<br>$\frac{P}{b}$                     | 1                 | 1.318 | 1.935 | 2.813  | 3.655  | 5.228  | .....  | .....  | 24    |       |                      |       |       |    |
| Hyperbolic logarithm of ratio of compression.   | $\frac{\text{hyp log } l}{l}$ | From tables.                                  | .....             | .2761 | .6601 | 1.0343 | 1.2961 | 1.6540 | 1.7459 | 1.7429 | 26    |       |                      |       |       |    |
| Final cushion-pressure, pounds per square inch.   | <i>L</i>                      | $b \times l$                                  | 17.5              | 23.1  | 33.9  | 49.2   | 64     | 91.5   | 100    | 100    | 27    |       |                      |       |       |    |
| Mean absolute cushion-pressure, pounds per square inch.   | <i>k</i>                      | $L \times \frac{\text{hyp log } l}{l-1}$      | .....             | 20    | 23.9  | 28.1   | 31.2   | 35.8   | 37     | 37     | 28    |       |                      |       |       |    |
| Mean pressure, corrected for back-pressure, clearance, and cushion, pounds per square inch.   | <i>t</i>                      | $n - \frac{c}{100} \times (l-1) \times (k-b)$ | 76.7              | 74.5  | 63.9  | 50.6   | 41.7   | 28.1   | 20.5   | 12.4   | 29    |       |                      |       |       |    |
| Probable mean effective pressure, pounds per square inch.   | <i>e</i>                      | .95 <i>X t</i>                                | 72.9              | 70.8  | 60.7  | 48.1   | 39.6   | 26.7   | 19.5   | 11.8   | 30    |       |                      |       |       |    |
| Horse-power for pressure <i>e</i> , each square inch of effective piston-area.  | <i>H</i>                      | $\frac{e \times B}{33,000}$                   | .995              | .967  | .828  | .656   | .540   | .364   | .266   | .161   | 31    |       |                      |       |       |    |

XXI.—(Continued.)

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

| Symbol.  | Formula.                                   | POINT OF CUT-OFF. |        |       |        |        |        |        |        |      |   |   | Number for Reference. |  |  |  |  |
|--|--|-------------------|--------|-------|--------|--------|--------|--------|--------|------|---|---|-----------------------|--|--|--|--|
|  |  | z                 | y      | x     | w      | v      | u      | t      | s      | r    | q | p |                       |  |  |  |  |
| Effective cross-section of cylinder, square inches.                            | $\frac{E}{H}$                              | 150.8             | 181.2  | 228.7 | 277.8  | 412.1  | 563.9  | 931.7  | 32     |      |   |   |                       |  |  |  |  |
| Actual cross-section of cylinder, square inches for effective section $\phi$ . | $\frac{27}{29}$                            | 153.2             | 184.1  | 232.4 | 282.2  | 418.7  | 572.9  | 946.6  | 33     |      |   |   |                       |  |  |  |  |
| Diameter of cylinder, inches to nearest quarter-inch.                          | $a - (.018 \times \sqrt{P})^2$             | 14                | 14.25  | 15.25 | 17.25  | 19     | 23     | 27     | 34.75  | 34   |   |   |                       |  |  |  |  |
| Stroke, inches.  | $\sqrt{\frac{A}{.7854}} \times 2 \times D$ | 28                | 28.5   | 30.5  | 34.5   | 38     | 46     | 54     | 69.5   | 35   |   |   |                       |  |  |  |  |
| Diameter of piston-rod, inches to nearest sixteenth-inch.                      | $.018 \times D \times \sqrt{P}$            | 2.5               | 2.5625 | 2.75  | 3.125  | 3.4375 | 4.125  | 4.875  | 6.25   | 36   |   |   |                       |  |  |  |  |
| Cross-section of cylinder, square inches, revised value.                       | $.7854 \times D^2$                         | 153.9             | 159.5  | 182.7 | 233.7  | 283.5  | 415.5  | 572.6  | 948.4  | 37   |   |   |                       |  |  |  |  |
| Cross-section of piston-rod, square inches.                                    | $.7854 \times \phi^2$                      | 4.9               | 5.2    | 5.9   | 7.7    | 9.3    | 13.4   | 18.7   | 30.7   | 37.6 |   |   |                       |  |  |  |  |
| Effective cross-section of cylinder, square inches, revised value.             | $2 \times \frac{(A) - o}{(q)}$             | 151.5             | 156.9  | 179.8 | 224.9  | 278.9  | 408.8  | 563.3  | 933.1  | 38   |   |   |                       |  |  |  |  |
| Probable effective horse-power.  | $\frac{e \times (q) \times V}{33,000}$     | 150.6             | 151.5  | 148.8 | 147.5  | 150.6  | 148.8  | 149.8  | 150.1  | 39   |   |   |                       |  |  |  |  |
| Clearance in equivalent length of cylinder, inches, revised value.             | $\frac{c}{100} \times S$                   | .98               | 1.     | 1.07  | 1.21   | 1.24   | 1.38   | 1.35   | 1.74   | 40   |   |   |                       |  |  |  |  |
| Volume of clearance-space at each end, cubic feet.                             | $(c) \times (q)$                           | .0859             | .0906  | .111  | .157   | .199   | .326   | .440   | .938   | 41   |   |   |                       |  |  |  |  |
| Volume of cylinder and clearance at one end up to .95 stroke, cubic feet.      | $\frac{.95 \times (q) \times S}{1728} + N$ | 2.418             | 2.549  | 3.126 | 4.423  | 6.026  | 10.665 | 17.163 | 36.591 | 42   |   |   |                       |  |  |  |  |
| Number of strokes per hour.  | $\frac{V \times 12 \times 60}{S}$          | 11571             | 11368  | 10623 | 9391   | 8526   | 7043   | 6000   | 4662   | 43   |   |   |                       |  |  |  |  |
| Absolute pressure at .05 stroke, pounds per square inch.                       | $\frac{1}{r} + \frac{c}{100} \times C$     | 91                | 83     | 51.6  | 36.1   | 28.1   | 19.7   | 15.2   | 11     | 44   |   |   |                       |  |  |  |  |
| Weight in pounds of a cubic foot of steam at pressure $B_1$ .                  | $\frac{.95 + c/100}{B_1}$ from tables.     | .2107             | .1932  | .1223 | .08830 | .06978 | .04998 | .04109 | .02891 | 45   |   |   |                       |  |  |  |  |

XXI.—(Continued.)

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

| Symbol.   | Formula.  | POINT OF CUT-OFF. |               |               |               |               |               |               |               |                |                | Number for Reference. |
|---|---|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|----------------|-----------------------|
|   |   | $\frac{1}{2}$     | $\frac{1}{3}$ | $\frac{1}{4}$ | $\frac{1}{5}$ | $\frac{1}{6}$ | $\frac{1}{7}$ | $\frac{1}{8}$ | $\frac{1}{9}$ | $\frac{1}{10}$ | $\frac{1}{11}$ |                       |
| Weight in pounds of a cubic foot of steam at pressure $L$ .                                   | From tables.  | .04472            | .05805        | .08323        | .1181         | .1513         | .2118         | .2303         | .2303         | .2303          | .2303          | 46                    |
| Pounds of steam used hourly, calculated by piston-displacement.                               | $w \times (v \times W - N \times w)$  | 3851              | 5539          | 3963          | 3494          | 3328          | 3268          | 3627          | 3627          | 3627           | 3627           | 47                    |
| Mean total pressure during expansion, pounds per square inch.                                 | $C \times \frac{\text{hyp log } R}{R - 1}$  | .....             | 80.3          | 67.1          | 55.1          | 47.6          | 38.3          | 32.2          | 26.3          | 26.3           | 26.3           | 48                    |
| Ratio of mechanical effect during expansion to total mechanical effect.                       | $\frac{U \times (r - 1)}{r \times (n + b)}$   | .....             | .218          | .411          | .534          | .591          | .666          | .699          | .749          | .749           | .749           | 49                    |
| Units of heat required hourly for the work of expansion.                                      | $\frac{772}{(n + b) \times I \times (q) \times S/12 \times w}$  | .....             | 110052        | 189649        | 274063        | 348205        | 456091        | 554981        | 687080        | 687080         | 687080         | 50                    |
| Latent heat per pound of steam at pressure $B$ , British thermal units.                       | From tables.  | .....             | 893           | 916           | 931           | 942           | 955           | 965           | 976           | 976            | 976            | 51                    |
| Pounds of steam condensed hourly for work of expansion.                                       | $\frac{i}{(C)}$   | .....             | 124           | 207           | 294           | 370           | 477           | 575           | 704           | 704            | 704            | 52                    |
| Thickness of piston, inches, to nearest half-inch.  | $\frac{T}{4D}$  | 3.5               | 4             | 4             | 4             | 4.5           | 5             | 5             | 5             | 5              | 5              | 53                    |
| Internal condensing surface, square feet.   | $2 \times (A) \times \frac{144}{S + (T) + 2 \times (P) + 3.1416 \times \frac{D}{12} \times \frac{S + (P)}{12} + 3.1416 \times \frac{P}{12} \times \frac{S + (P)}{12}$ | 18.9              | 19.7          | 22.4          | 28.4          | 34.5          | 50.3          | 68.7          | 113.3         | 113.3          | 113.3          | 54                    |
| Probably condensation hourly, on internal surfaces, pounds.                                   | $15 \times (a)$   | 284               | 296           | 336           | 426           | 518           | 755           | 1032          | 1700          | 1700           | 1700           | 55                    |
| Probable consumption of steam hourly, pounds } Total.. } Per effective } horse-power... } (H) | $Q + \frac{(C)}{(w)} + \frac{(d)}{(H)}$   | 6135              | 5959          | 4506          | 4214          | 4216          | 4500          | 5234          | 6329          | 6329           | 6329           | 56                    |
|   |   | 40.7              | 39.3          | 30.3          | 28.6          | 28            | 30.2          | 34.9          | 42.2          | 42.2           | 42.2           | 57                    |

XXI.—(Continued.)

CONDENSING ENGINES, DRY SATURATED STEAM, UNJACKETED CYLINDERS.

|  | Symbol.  | Formula. | POINT OF CUT-OFF. |               |               |               |               |               |               |               |               |               |  |  |  |
|--|----------|----------|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|--|--|--|
|  |          |          | Full Stroke.      | $\frac{3}{4}$ | $\frac{2}{3}$ | $\frac{1}{2}$ | $\frac{1}{3}$ | $\frac{1}{4}$ | $\frac{1}{5}$ | $\frac{1}{6}$ | $\frac{1}{7}$ | $\frac{1}{8}$ |  |  |  |
| Mean pressure, pounds per square inch. . . . .   | $M$      | 22       | 90.5              | 88.4          | 78.3          | 65.9          | 57.7          | 45.4          | 37.7          | 29.8          |               |               |  |  |  |
| Corrected for back-pressure and clearance. . . . .   | $N$      | 23       | 90.2              | 88.0          | 77.5          | 64.7          | 56.3          | 43.8          | 36.1          | 28.0          |               |               |  |  |  |
| Ratio of compression. . . . .  | $r$      | 20       | 1                 | 1.318         | 1.935         | 2.813         | 3.655         | 5.228         | 6.833         | 9.464         |               |               |  |  |  |
| Hyperbolic logarithm of ratio of compression. . . . .  | $\log r$ | 21       | —                 | .2761         | .6601         | 1.0343        | 1.2961        | 1.654         | 1.9218        | 2.2475        |               |               |  |  |  |
| Final cushion-pressure, pounds per square inch. . . . .  | $L$      | 27       | 4.5               | 5.9           | 8.7           | 12.6          | 16.4          | 23.5          | 30.7          | 42.6          |               |               |  |  |  |
| Mean absolute cushion-pressure, pounds per square inch. . . . .                                    | $k$      | 28       | —                 | 5.1           | 6.1           | 7.2           | 8.0           | 9.2           | 10.1          | 11.3          |               |               |  |  |  |
| Mean pressure, corrected for back-pressure, clearance and cushion, pounds per square inch. . . . . | $t$      | 29       | 90.2              | 88.0          | 77.4          | 64.5          | 56.0          | 43.2          | 35.3          | 26.6          |               |               |  |  |  |
| Probable mean effective pressure, pounds per square inch. . . . .                                  | $e$      | 30       | 85.7              | 83.6          | 73.5          | 61.3          | 53.2          | 41.0          | 33.5          | 25.3          |               |               |  |  |  |
| Probable effective horse-power. . . . .  | $(E)$    | 39       | 177               | 178.9         | 186.2         | 188           | 202.3         | 228.6         | 257.3         | 321.9         |               |               |  |  |  |
| Calculated by piston-displacement. . . . .   | $Q$      | 47       | 5883              | 5582          | 4934          | 3611          | 3506          | 3619          | 4031          | 4480          |               |               |  |  |  |
| Condensed for the work of expansion. . . . .   | $(C)$    | 52       | —                 | 124           | 207           | 294           | 370           | 477           | 575           | 704           |               |               |  |  |  |
| Condensed on internal condensing surfaces. . . . .   | $(d)$    | 25(a)    | 473               | 493           | 560           | 710           | 863           | 1258          | 1718          | 2833          |               |               |  |  |  |
| Total. . . . .   | $(w)$    | 56       | 6356              | 6199          | 4801          | 4615          | 4739          | 5354          | 6324          | 8017          |               |               |  |  |  |
| Per effective horse-power. . . . .   | $(W)$    | 57       | 35.9              | 34.7          | 26.6          | 24.5          | 23.4          | 23.4          | 24.6          | 24.8          |               |               |  |  |  |



XXI.—(Continued.)

CONDENSING ENGINES, DRY SATURATED STEAM, UNJACKETED CYLINDERS, 150 EFFECTIVE HORSE-POWER, 100 POUNDS INITIAL PRESSURE, 4½ POUNDS BACK-PRESSURE.

|  |  | POINT OF CUT-OFF. |               |               |               |               |               |               |               |               |                |
|--|--|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|
|  |  | Full Stroke.      | $\frac{3}{4}$ | $\frac{2}{3}$ | $\frac{1}{2}$ | $\frac{1}{3}$ | $\frac{1}{4}$ | $\frac{1}{5}$ | $\frac{1}{6}$ | $\frac{1}{8}$ | $\frac{1}{10}$ |
|  | Formula.   |                   |               |               |               |               |               |               |               |               |                |
|  | Symbol.  |                   |               |               |               |               |               |               |               |               |                |
| Trial data.  | { Mean effective pressure.....<br>Cross-section of cylinder, square inches....<br>Diameter of cylinder, inches, to nearest $\frac{1}{4}$ "...<br>Stroke, inches.....<br>Fraction of clearance.....   | 13                | 88            | 77.7          | 64.1          | 54.5          | 41.8          | .34           | 24.8          |               |                |
|  |  | 15                | 121.55        | 141.57        | 171.61        | 201.84        | 263.16        | 323.53        | 443.55        |               |                |
| P r cent of clearance.                               | { P r cent of clearance to nearest $\frac{1}{4}$ ".....<br>Real ratio of expansion and ratio of compression...   | 16                | 12½           | 13½           | 14½           | 16            | 18½           | 20½           | 23½           |               |                |
|  |  | 17                | 25            | 27            | 29½           | 32            | 36½           | 40½           | 47½           |               |                |
| Hyperbolic logarithm of preceding.                   | { Hyperbolic logarithm of preceding.....<br>Probable mean effective pressure.....<br>Diameter of cylinder, inches, to nearest $\frac{1}{4}$ ".....<br>Stroke, inches.....<br>Diameter of piston-rod, inches, to nearest $\frac{1}{16}$ ".....<br>Cross-section of cylinder, square inches.....<br>Effective..... | 18                | .0375         | .0394         | .0381         | .0311         | .0355         | .0340         | .0355         |               |                |
|  |  | 19                | 3½            | 4             | 4             | 3½            | 3½            | 3½            | 3½            | 3½            |                |
| Probable effective horse-power.                      | { Probable effective horse-power.....<br>Cylinder and clearance, up to $\frac{9}{10}$ stroke.....<br>Clearance.....<br>Final cushion.....<br>At $\frac{9}{10}$ stroke.....   | 20,24             | 1             | 1.3165        | 1.9259        | 2.7078        | 3.6087        | 5.1322        | 6.4687        | 8.7465        |                |
|  |  | From tabl's       | —             | .2753         | .6554         | 1.0289        | 1.2834        | 1.6355        | 1.867         | 2.1686        |                |
| Volume, cubic feet.                                  | { Volume, cubic feet.....<br>Cylinder and clearance, up to $\frac{9}{10}$ stroke.....<br>Clearance.....<br>Final cushion.....<br>At $\frac{9}{10}$ stroke.....   | 30                | 85.6          | 73.6          | 61.4          | 52.7          | 41.2          | 34.4          | 25.8          |               |                |
|  |  | 34                | 13            | 13½           | 14            | 15½           | 16½           | 18½           | 20½           | 23½           |                |
| Absolute pressures.                                  | { Absolute pressures.....<br>At $\frac{9}{10}$ stroke.....   | 35                | 26            | 26½           | 30½           | 33            | 37            | 40½           | 47            |               |                |
|  |  | 36                | 2½            | 2½            | 2½            | 3             | 3             | 3½            | 3½            | 4½            |                |
| Number of strokes per hour.                          | { Number of strokes per hour.....  | 37                | 132.73        | 137.89        | 159.94        | 182.65        | 213.83        | 268.8         | 322.06        | 433.74        |                |
|  |  | 38                | 130.63        | 135.67        | 151.48        | 179.68        | 210.29        | 264.49        | 316.9         | 426.64        |                |
| Cylinder and clearance, up to $\frac{9}{10}$ stroke. | { Cylinder and clearance, up to $\frac{9}{10}$ stroke.....<br>Clearance.....<br>Final cushion.....<br>At $\frac{9}{10}$ stroke.....  | 39                | 152.5         | 154.3         | 152           | 150.4         | 151.1         | 148.6         | 148.7         | 150.1         |                |
|  |  | 42                | .941          | .06           | 2.43          | 3.132         | 3.966         | 5.578         | 7.316         | 11.309        |                |
| Final cushion.                                       | { Final cushion.....<br>At $\frac{9}{10}$ stroke.....  | 41                | .0737         | .0832         | .0982         | .119          | .151          | .198          | .26           | .402          |                |
|  |  | 27                | 4.5           | 5.9           | 8.7           | 12.6          | 16.2          | 23.1          | 29.1          | 39.4          |                |
| At $\frac{9}{10}$ stroke.                            | { At $\frac{9}{10}$ stroke.....  | 44                | 91            | 73.8          | 51.8          | 36.2          | 28.4          | 20.1          | 16            | 11.9          |                |
|  |  | 43                | 12752         | 12226         | 11571         | 10623         | 9818          | 8759          | 8000          | 6968          |                |

XXI.—(Continued.)

CONDENSING ENGINES, DRY SATURATED STEAM, UNJACKETED CYLINDERS, 150 EFFECTIVE HORSE-POWER, 100 POUNDS INITIAL PRESSURE, 4½ POUNDS BACK-PRESSURE.—(Continued.)

|  | Symbol. | Formula.    | POINT OF CUT-OFF. |       |        |        |        |        |        |        |
|--|---------|-------------|-------------------|-------|--------|--------|--------|--------|--------|--------|
|  |         |             | ¾                 | ⅔     | ½      | ¼      | ⅓      | ⅕      | ⅙      |        |
| Weight of steam per cubic foot, pounds.                      | $w$     | From tables | .01249            | .0161 | .02319 | .03285 | .04159 | .05805 | .07211 | .09586 |
| Pounds of steam hourly, calculated by piston-displacement.   | $W$     | From tables | .2107             | .173  | .124   | .08603 | .07048 | .05993 | .04111 | .03113 |
| Latent heat per pound of steam at pressure $B$ .             | $Q$     | 47          | 5203              | 4330  | 3460   | 2821   | 2683   | 2387   | 2256   | 2185   |
| British thermal units.                                       | $(f)$   | From tables | —                 | 899   | 916    | 931    | 941    | 955    | 963    | 973    |
| Pounds of steam condensed hourly for work of expansion.      | $(C)$   | 52          | —                 | 106   | 194    | 249    | 281    | 313    | 339    | 390    |
| Thickness of piston, inches, to nearest ⅓".                  | $(T)$   | 53          | 3½                | 3½    | 3½     | 4      | 4      | 4½     | 4½     | 5      |
| Internal condensing surface, square feet.                    | $(a)$   | 54          | 16.3              | 16.9  | 18.8   | 22.4   | 25.8   | 32.8   | 39.1   | 52.1   |
| Probable condensation, hourly, on internal surfaces, pounds. | $(d)$   | 25X(a)      | 408               | 424   | 471    | 561    | 645    | 819    | 976    | 1304   |
| Probable consumption of steam, hourly, pounds.               | $(zw)$  | 56          | 5611              | 4860  | 4125   | 3631   | 3609   | 3519   | 3571   | 3879   |
| Per effective horse-power.                                   | $(W)$   | 57          | 36.8              | 31.5  | 27.1   | 24.1   | 23.9   | 23.7   | 24     | 25.8   |

XXI.—(Continued.)  
NON-CONDENSING ENGINES, DRY SATURATED STEAM-JACKETED CYLINDERS.

|   | Symbol.                                   | Formula.   | POINT OF CUT-OFF. |               |               |               |               |               |                | Number for Reference. |
|---|---|--|-------------------|---------------|---------------|---------------|---------------|---------------|----------------|-----------------------|
|   |   |  | Stroke            | $\frac{3}{4}$ | $\frac{1}{2}$ | $\frac{1}{4}$ | $\frac{1}{6}$ | $\frac{1}{8}$ | $\frac{1}{10}$ |                       |
| Sixteenth root of real cut-off. . . . .   | $\left(\frac{1}{R}\right)^{\frac{1}{16}}$ |  | .98287            | .95960        | .93747        | .92219        | .90169        | .88682        | .87031         | 58                    |
| Mean pressure for stroke, plus clearance, corrected for back-pressure, pounds per square inch.<br>{ When final cushion-pressure is less than initial pressure. To make final cushion-pressure and initial pressure equal. } | $M$                                       | $m + 16 \times C \times \frac{\left[\left(\frac{1}{R}\right)^{\frac{1}{16}} - \left(\frac{1}{R}\right)^{\frac{1}{8}}\right]}{R} - b$ | 77.5              | 74.7          | 64.6          | 51.8          | 42.7          | 30.8          | 23.1           | 59                    |
| Ratio of compression.<br>{ When final cushion-pressure is less than initial pressure. To make final cushion-pressure and initial pressure equal. }  | $L$                                       | Assumed.<br>$\left(\frac{P}{P'}\right)^{\frac{1}{16}}$   | . . . . .         | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .      | 60                    |
| Seventeenth power of sixteenth root of ratio of compression. . . . .  | $L^{\frac{17}{16}}$                       |  | . . . . .         | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .      | 61                    |
| Final cushion-pressure, pounds per square inch. . . . .   | $L$                                       | $b \times L^{\frac{17}{16}}$   | . . . . .         | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .      | 62                    |
| Sixteenth root of reciprocal of ratio of compression. . . . .   | $\left(\frac{1}{L}\right)^{\frac{1}{16}}$ |  | 17.5              | 23.5          | 35.3          | 52.5          | 69.4          | 100           | 100            | 63                    |
| Absolute cushion-pressure, pounds per square inch. . . . .  | $k$                                       | $16 \times \left[1 - \left(\frac{1}{L}\right)^{\frac{1}{16}}\right] \frac{1}{L-1}$   | . . . . .         | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .      | 64                    |
| Ratio of expansion up to .95 stroke. . . . .  | —   | $C \times \left(\frac{1 + \frac{c}{100}}{.95 + \frac{c}{100}}\right)^{\frac{1}{16}}$   | . . . . .         | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .      | 65                    |
| Absolute pressure at .95 stroke, pounds per square inch. . . . .  | $B$                                       | $C \times \left(\frac{1/2 + c/100}{.95 + c/100}\right)^{\frac{1}{16}}$   | . . . . .         | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .     | . . . . .      | 66                    |
| Weight in pounds of a cubic foot of steam at pressure $B$ . . . . .   | $W$                                       | From tables.   | 2107              | .1705         | .1193         | .08346        | .06464        | .04544        | .03505         | 67                    |
| Weight in pounds of a cubic foot of steam at pressure $L$ . . . . .   | $w$                                       | From tables.   | .04472            | .05899        | .08646        | .1256         | .1653         | .2303         | .2303          | 68                    |

XXI.—(Continued.)  
NON-CONDENSING ENGINES, DRY SATURATED STEAM-JACKETED CYLINDERS.

|   | Symbol. | Formula.  | POINT OF CUT-OFF. |      |      |      |      |       |       |       |     |     | Number for Reference. |
|---|---------|---|-------------------|------|------|------|------|-------|-------|-------|-----|-----|-----------------------|
|   |         |   | Stroke            | 3/4  | 3/8  | 1/2  | 3/4  | 1/2   | 3/8   | 1/4   | 1/6 | 1/8 |                       |
| Felted surface, square feet.....                                      | (a)     | Assumed.<br>$\pi \times \frac{(A)}{144}$  | 18.9              | 19.7 | 22.4 | 28.4 | 34.5 | 50.3  | 68.7  | 113.3 | 70  |     |                       |
| Unfelted surface, square feet.....                                    | (f)     | $+ 3.1416 \times \frac{d}{12} \times \frac{S + (P)}{12}$                                | 3.7               | 3.9  | 4.4  | 5.7  | 6.9  | 10.1  | 13.8  | 22.9  | 71  |     |                       |
| External temperature of jacket, Fahr.....                             | (t)     | Assumed.  | 70°               | 70°  | 70°  | 70°  | 70°  | 70°   | 70°   | 70°   | 72  |     |                       |
| Internal temperature of jacket, Fahr.....                             | (l)     | From tables.  | 328°              | 328° | 328° | 328° | 328° | 328°  | 328°  | 328°  | 73  |     |                       |
| Latent heat of steam in jacket, British thermal units per pound.      | (L)     | From tables.  | 884               | 884  | 884  | 884  | 884  | 884   | 884   | 884   | 74  |     |                       |
| Heat lost by condensation hourly, }<br>British thermal units. } ..... | (Q)     | $1.1 \times \{ (a) \times [(l) - (t)] \times .5 + (f) \times [(l) - (t)] \times 2.5 \}$ | 5397              | 5563 | 6300 | 8074 | 9791 | 14304 | 19359 | 32325 | 75  |     |                       |
| Probable amount of steam condensed in jacket hourly, pounds. }        | (K)     | $\frac{(Q) + 1.1 \times f}{(L)}$  | 6                 | 143  | 243  | 350  | 444  | 595   | 713   | 892   | 76  |     |                       |
| Probable consumption of steam hourly, lbs. }                          | (w)     | $Q + (K)$   | 5857              | 5023 | 4103 | 3631 | 3488 | 3479  | 3714  | 4225  | 77  |     |                       |

|   | Symbol. | POINT OF CUT-OFF. |      |       |       |       |       |      |       |     |     | No. of Revs. |
|---|---------|-------------------|------|-------|-------|-------|-------|------|-------|-----|-----|--------------|
|   |         | Full Stroke       | 3/4  | 3/8   | 1/2   | 3/4   | 1/2   | 3/8  | 1/4   | 1/6 | 1/8 |              |
| Mean pressure, corrected for back-pressure and clearance, pounds per square inch.           | #       | 76.7              | 73.8 | 63.4  | 50.1  | 40.8  | 28.7  | 21.2 | 13.2  | 23  |     |              |
| Mean pressure, corrected for back-pressure, clearance, and cushion, pounds per square inch. | z       | 76.7              | 73.8 | 63.2  | 49.4  | 39.5  | 26.2  | 19.1 | 11.1  | 29  |     |              |
| Probable mean effective pressure, pounds per square inch.                                   | z       | 72.9              | 70.1 | 60    | 46.9  | 37.5  | 24.9  | 18.1 | 10.5  | 30  |     |              |
| Probable effective horse-power  | (E)     | 150.6             | 150  | 147.1 | 143.8 | 142.6 | 139.4 | 139  | 133.6 | 39  |     |              |
| Pounds of steam used hourly, calculated by piston-displacement.....                         | (Q)     | 5851              | 4880 | 3860  | 3281  | 3044  | 2884  | 3004 | 3333  | 47  |     |              |
| Probable consumption of steam hourly, per effective horse-power.....                        | (W)     | 38.9              | 33.5 | 27.9  | 25.2  | 24.5  | 25.1  | 26.7 | 31.6  | 57  |     |              |





XXI.—(Continued.)

NON-CONDENSING ENGINES, UNJACKETED CYLINDERS, STEAM SUPERHEATED SUFFICIENTLY TO PREVENT CONDENSATION.

|   | Symbol. | POINT OF CUT-OFF. |               |               |               |               |               |               | Ref. No. |    |
|---|---------|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|----------|----|
|   |         | Full Stroke       | $\frac{3}{4}$ | $\frac{1}{2}$ | $\frac{1}{3}$ | $\frac{1}{4}$ | $\frac{1}{5}$ | $\frac{1}{6}$ |          |    |
| Probable effective horse-power.                                 | (E)     | 150.6             | 151.5         | 148.8         | 147.5         | 150.6         | 148.8         | 149.8         | 150.1    | 39 |
| Pounds of steam used hourly, calculated by piston-displacement. | Q       | 5851              | 5539          | 3963          | 3494          | 3328          | 3268          | 3627          | 3925     | 47 |
|   | (W)     | 38.8              | 36.6          | 26.6          | 23.7          | 22.1          | 22            | 24.2          | 26.1     | 57 |

| Point of Cut-off. | Pounds of steam hourly. | Effective horse-power. | Pounds of steam hourly, per effective horse-power. |
|-------------------|-------------------------|------------------------|--|
| Full stroke.      | 5883                    | 177                    | 33.2   |
| $\frac{3}{4}$     | 5582                    | 178.9                  | 31.2   |
| $\frac{1}{2}$     | 4034                    | 180.2                  | 22.4   |
| $\frac{1}{3}$     | 3611                    | 188                    | 19.3   |
| $\frac{1}{4}$     | 3506                    | 202.3                  | 17.3   |
| $\frac{1}{5}$     | 3619                    | 228.6                  | 15.9   |
| $\frac{1}{6}$     | 4031                    | 257.3                  | 15.7   |
| $\frac{1}{8}$     | 4480                    | 321.9                  | 13.9   |

















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