eye of the seat projection. The seat and saddletree are thus simply and firmly connected together.

Ole H. Larson, of Fort Dodge, Iowa, has patented a Ventilating Beer Faucet. A flexible tube with split bulb, and connected with the outside air, forms part of the faucet, and is forced into the liquid where the bulb floats on the surface, thus admitting of a free passage of air. It is an ingenious and good device.

Mr. William A. Cates, of Union, Oregon, has devised an ingenious clock, the dial of which is so subdivided as to indicate the 24 hours of the day. It is arranged with a revolving face plate having a map of the earth on a polar projection, the face plate being placed on the hub of the hour hand. A loosely moving and graduated index hand is placed on the hub of the hour wheel, for indicating the time and geographical position of any place on the earth.

Mr. Daniel G. Beers, of Sandy Hook, Conn., is the inventor of an improved clothes wringer so constructed as to allow the rollers to spread while operating upon large or thick fabrics without throwing the gear wheels out of engagement.

Zelotes McKinler & Virgil True, of Laclede, Mo., have patented a Gas Stove, which is designed to provide an economical form of cooking stove especially adapted to small families and for summer use. It generates its own gas from a burner, without the use of a wick, by volatilizing, through the heat of the burner, a limited quantity of the volatile oil admitted to the burner from a reservoir placed above the same. The improvements consist in the particular construction and arrangement of the pipes with respect to the reservoir and the supports or stoves for the cooking utensils.

John Miller, of Petersburgh, Pa., and William B. Miller, of Altoona, Pa., have patented a Shaft Tug, an improvement upon that form of shaft tug which is provided with an internal protector to receive the wear of the shaft; and it consists in the peculiar construction and arrangement of the parts whereby the protector may be taken out and replaced, when worn, without deranging or destroying the tug strap.

A Pill Machine invented by Dr. John Hill of South Norwalk, Conn., consists of a series of blades fixed to a vibrating bar, and adapted for dividing the rolls of pill mass upon a tablet, in combination with pivoted clearers which separate the mass from the cutters. The bits of pill mass are then rolled into pills in the ordinary way.

John W. Drake of Tolono, Ill., has invented an improved lamp shade and reflector, which by an efficient arrangement of conical sections and reflectors throws a strong light through the opening of the shade.

On the base of a buckle patented by T. L. Wiswell, of Olathe, Kan., is formed a hook. The end of the strap passes through the buckle, enters the hook and rests upon the ring it holds, so that it is impossible to detach the hook without loosening the strap. It is strong and the buckle does not need to be sewed on.

An air feeder for stoves has been invented by G. C. Palm, of Andersonburg, Penn., which supplies the air for combustion from outside the house. An air trough beneath the floor leading out to the outer air is connected with an air box under the stove. This box is provided with partitions, dampers, doors and two outlet pipes. One outlet pipe is connected with a sunken air chamber under the stove and the other with the bottom of the hearth. The former supplies heated air to a heater above the stove and the latter furnishes the draft.

Communications.

The Law of the Pressure of Saturated Steam with Relation to Temperature.

To the Editor of the Scientific American:

The exact law of the connection between the pressure and temperature of saturated steam has hitherto eluded discovery, notwithstanding the numerous and admirable investigations and experiments instituted on the important subject; and the respective values relied upon for practical purposes have been derived from empirical formulæ more or less simple or complex in proportion as less or greater exactness is required. I think that I have discovered the true nature of the relation in question, a result which I have obtained with the aid and on the ground of the views and conclusions set forth in my recently published pamphlet, "Nature of the Physical Forces" (Rosnan & Co., San Francisco, Cal.). The following is a brief statement of the principal facts involved.

The unit of weight of a given volume of a gas is, according to my deductions, and in conformity with the kinetic theory, equal to the square root of the weight of volume. Multiples of volume, as 2...3...4, etc., therefore involve an increase of the unit of weight at the rate of the square roots of the numbers, respectively by 1·4142....1·732....2, etc. If the number of volumes is increased, while the space occupied by them remains that of one volume, the force of expansion, which is equivalent to pressure, will increase in proportion to the weight of the number of volumes; the units of weight increasing only at the rate of the square roots of these numbers. The increase of volumes of steam in a steam boiler, consequent on the continued application of heat, is of this nature; and the pressure being at 100° C., that of 1 volume, whose weight is equal to that of a column of mercury 760 mm. high and = 1 atmosphere, is at 120° C. = 1491 mm., or nearly 2 atmospheres, at 135° C. = 3 atmospheres, etc., the units of weight being $\sqrt{760} = 27{\cdot}568$ for 1 atmosphere; $\sqrt{2 \times 760}$, or $1{\cdot}41 \times 27{\cdot}568$ for 2 atmospheres; $\sqrt{3 \times 760}$, or $1{\cdot}73 \times 27{\cdot}568$ for 3 atmospheres, etc.

The power by which additional volumes are constantly forced into the same space is increase of temperature, and it remains to be shown that the units of heat actually increase at the same rate as the units of weight of the volumes of steam, and thus to illustrate in the most striking manner the truth of the mechanical equivalence of heat.

The temperatures really increase at the rate indicated; in order to render this manifest, it is only necessary to divide the squares of temperature expressed in degrees of the centigrade scale, by 10,000. In the following, the quotients thus obtained are compared with the square roots of the units of the pressure corresponding to the temperature according to Regnault. The first column contains the temperatures; the second the units of pressure in atmospheres; the third the squares of temperature divided by 10,000; the fourth the roots of units of pressure.

100° C.	1·000	1·0000	1·0000	195° C.	13·84	3·8025	3·7198
120° C.	1·962	1·44	1·4000	200° C.	15·38	4·0000	3·9211
135° C.	3·097	1·8225	1·7579	205° C.	17·00	4·2025	4·1231
145° C	4·11	2·1025	2·0259	210° C.	18·85	4·4100	4·3414
160° C.	6·12	2·5600	2·4729	215° C.	20·8	4·6225	4·5604
165° C.	6·94	2·7225	2·6339	220° C.	22·88	4·8400	4·7831
170° C.	7·844	2·89	2·7998	225° C.	25·00	5·0625	5·0000
175° C.	8·83	3·0625	2·9708	230° C.	27·5	5·2900	5·2438
185° C.	11·12	3·4225	3·3343				

The values of the units of temperatures corresponding to the square roots of the units of pressure are slightly but uniformly in excess of the values of the latter, which discrepancy will be accounted for presently; of the existence of the exact relation there can be no doubt; and this very simple relation expressed in general terms is as follows:

The temperatures are as the square roots of the number of units of pressure; the pressure is proportional to the total weight of volumes, which is equal to the square of the square root of the number of volumes multiplied by the unit of weight; and the square of the temperature (t) divided by 10000, is the square root of the number of compressed volumes, or $p = \left(\frac{t^2}{10000}\right)^2 \times 760$; and inversely, the square root of the number (n) of units of pressure, multiplied by 10000, is the square whose root represents the temperature at the pressure of n units, or $t = \sqrt{\sqrt{n} \times 10000}$.

A comparison of the values of t and p calculated from these formulæ, with the values actually found by experiment, will show if and to what degree the theory is in agreement with facts.

The first column of the following table exhibits the temperatures, from which the pressures of the second column have been calculated, and *vice versa*; the figures of the third column are the actual pressures, according to Regnault; the fourth shows the difference:

100° C.	760 mm.	760 mm.	
120° C.	1530 mm.	1491·28 mm.	38·72
135° C.	2523·2 mm.	2353·73 mm.	169·47
145° C.	3359·2 mm.	3125·55 mm.	233·65
160° C.	4980·73 mm.	4651·62 mm.	329·11
165° C.	5633·12 mm.	5274·54 mm.	358·58
170° C.	6347·59 mm.	5961·66 mm.	386
175° C.	7127·96 mm.	6717·43 mm.	410·53
185° C.	8899·66 mm.	8453·23 mm.	446·43
195° C.	10988·84 mm.	10519·63 mm.	469·2
200° C.	12160 mm.	11688·96 mm.	471
205° C.	13421·45 mm.	12955·66 mm.	465·79
210° C.	14780·546 mm.	14324·80 mm.	455·75
215° C.	16239·3 mm.	15801·33 mm.	438
220° C.	17803·156 mm.	17390·36 mm.	413
225° C.	19477·87 mm.	19097·04 mm.	380·83
230° C.	21267·916 mm.	20926·4 mm.	341·516

The figures show, as already stated, that the actual pressures are lower than those calculated from the temperatures; there has been a loss of temperature which has to be accounted for, if the doctrine of the mechanical equivalence of heat is to be rigorously true. The loss seems to be strongly confirmatory of the correctness of the law, as above enunciated; for when the pressure of the steam is indicated by the gauge, a certain amount of the expansive energy has already been consumed in the heating and expansion of the boiler, and the work thus performed is not included in the registered tension. The discrepancies, therefore, enter as a necessary factor for the determination of the values. The loss, as will be seen, increases gradually till at about 14 atmospheres it reaches a maximum, and, after remaining nearly stationary between 14 and 17 atmospheres, gradually diminishes. This seems to be in perfect agreement with the behavior of metals under strain, their power of resistance increasing gradually up to a maximum with the increase of the straining forces. Special investigations, however, are necessary to show that the discrepancies are solely due to this cause.

San Francisco, Cal., December, 1877. E. VOGEL.

The Telephone's Freaks Again.

To the Editor of the Scientific American:

We have just completed a line eleven miles long, from this place to Cape Girardeau, through a hilly, heavily timbered country, and are using the Bell telephone. At Cape Girardeau our wire passes in on the north side of a window and the wire of the Western Union Telegraph Company passes through the window on the south side, and that is as near as they come together any place on the line. If we listen in the telephone at Jackson we can hear every click made by the W. U. instrument, which is in the same room with the telephone, but in no way connected by wires. The telegraph instrument is secured to a small table and the telephone is fastened on a railing two feet distant.

Jackson, Mo. T. F. WHEELER.

Trueing a Crank Pin.

To the Editor of the Scientific American:

A quicker way of doing the job than that described by J. R., in issue of December 16, is this:

Set the crank shaft perfectly level; place the crank in a horizontal position, and apply a good level to the crank pin bearing. If you have no short level, true up parallel the edges of a strip of wood or metal, a trifle shorter than the crank pin bearing, and wide enough to clear the outside collar of the same; hollow out one of the edges, so that on placing the strip upon the bearing only the ends will touch; put the level on top, file away the high end of the pin till the parallel strip rests level, and by aid of a straight edge carefully file a flat place across the pin. This operation is repeated with the crank in vertical position, and, if you choose, with the same standing at an angle of 45°, both forward and back. With a pair of callipers find the smallest diameter across the flat places, and file the pin opposite to them to that diameter. Use the brasses or a template, the brasses being too large, in filing between the flat places to indicate the high spots, until you have the pin true and round.

I have followed this practice for a good many years with good success, both as to time required to do the work and the truth of it. JAMES LOCHER.

Two Brilliant Meteors.

To the Editor of the Scientific American:

After reading Dr. James' communication to your valuable paper of the 29th inst., I think it very probable that the meteorites in question were distinct, and the dates of observation correct. Within an hour of the time of falling I made a note of the occurrence, from which I wrote my communication to you. Besides, the meteor observed by Dr. James had "a slight deviation to the East," while the one seen by myself had an inclination of 65° to the West.

In regard to the cause of the green color, it may be proper to state that the fact that Dr. Smith, Pugh, Forchhammer, Bergemann and others have observed a fraction of 1 per cent (from 0·03 per cent to 0·45 per cent) of Cu and P, in various meteorites, may lead us to ascribe the phenomenon in question to those elements, although the amount observed be not sufficient to cause the appearance.

Racine, Wis. R. C. HINDLEY.

PRACTICAL MECHANISM.

BY JOSHUA ROSE, M.E.

NEW SERIES—NO. XXXVI.

GEAR WHEEL TEETH.

The designations of the various parts of a gear tooth may be understood from Fig. 256, in which A represents the face of a tooth, B the flank, C the point, D the root, E the depth, length, or height, F the breadth, G the thickness, and P P the pitch circle or pitch line, these last two terms being synonymous. When, however, this line is spoken of in con-

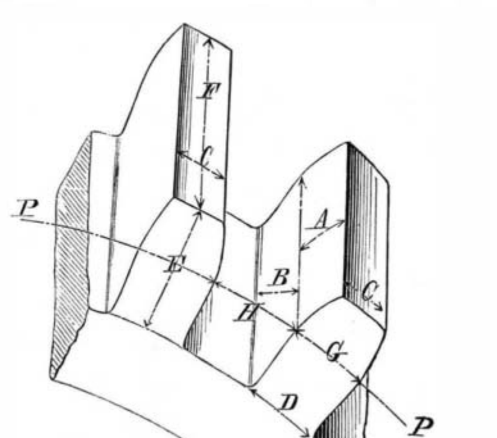

Fig. 256.

nection with a tooth it is termed the pitch line, but with the whole wheel, the pitch circle. The thickness of the tooth is always measured along the pitch line. The distance from the center of one tooth to the center of the next, measured along the pitch line, is termed the pitch, either of the wheel or of the teeth, as the case may be. The distance between one tooth and the next one measured on the pitch line, as at H, is called a space, and is equal to the thickness of the tooth and whatever clearance is allowed. (Clearance will be explained hereafter.)

The pitch of the teeth may be measured in two ways, one around the circumference of the pitch circle and the other straight across. It is evident that the first is an arc and the other a chord, hence the designations arc pitch and chordial pitch. Suppose that in Fig. 257 P P represents a portion of a pitch circle, and A, B, C, D the centers of teeth, then the distance between two of these centers, measured across E, is the chordial pitch, while that measured around the curvature of P P is the arc pitch. In a wheel having teeth it would be somewhat difficult to practically measure the arc pitch; hence when in the workshop the simple term "pitch" is used, it is understood to imply the chordial pitch, which can be measured with either a rule or pair of compasses. If it become necessary to obtain the arc pitch, the operator obtains it by calculation. If he is given the diameter of a wheel and the number of teeth it will contain, he divides the circumference by the number of teeth and thus obtains the arc pitch. He then sets his compasses to that pitch, and as a rule steps the compasses around the pitch circle, adjusting them until they mark the pitch circle off into exactly as many divisions as the required number of teeth, and thus obtains the chordial pitch. This, however, is a very delicate operation, since even in a wheel having but few teeth a very small error in the end of the compass points multiplies in the stepping, so that the last step taken will contain the error multiplied by as many times as there are teeth in the wheel. Indeed it is found impracticable to make a very fine adjustment by moving the compass points, and the plan adopted is to rub one side of the points with an oil stone slip, thus saving a great deal of time in the adjusting. To make a similar adjustment with compasses, one side of the pencil point may be eased off either with fine emery paper or a small fine file. It is obvious that the difference between the chordial and arc pitches decreases as the diameter of the wheel or the number of the teeth increases. It is found that in a wheel having 20 teeth it amounts to a little more than the one thousandth part of the radius, and that in a wheel of 40 teeth it is but about one eighth of what it was at 20. On the other hand, in pinions of less than 20 teeth the difference rapidly increases as the number of teeth decreases, and assumes great practical importance. When the number of teeth and the diameter of the wheel are given, we may set the compasses to space off the wheel correctly by the following construction: Let P P, in Fig. 258, be a portion of the pitch circle and A B a line drawn tangent to any part of it (care being taken to draw A B to exactly touch the perimeter of P P). Then from the point of contact (C) of A B with P P, mark off a distance equal to the arc pitch, producing the point D. Mark E = one fourth of C D; and from E as a center, mark the distance E D on P P, producing the point F. A straight line drawn from C to F, as denoted by G, marks the distance for the compass points to be set. Since the least error will make a great difference in spacing around the wheel, the lines must be drawn

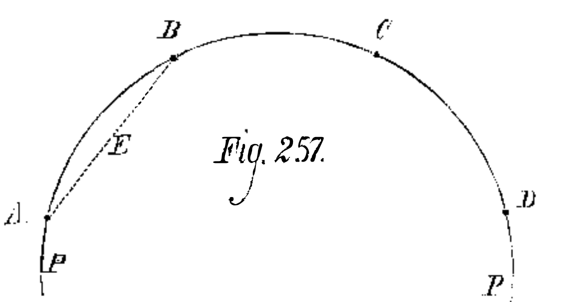

Fig. 257.

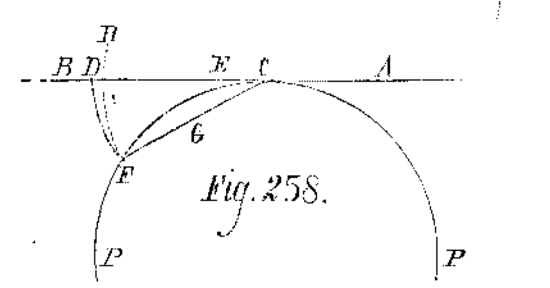

Fig. 258.

very fine, and the measurements made to great exactitude to render this method thoroughly reliable. To show the difference, in the case in point, between the arc and chordial pitches, we may, in this construction, set the compasses to the distance of C F and draw the segment of circle, H; and the distance between the line, H, and the point, D, on the line A B, is the difference in the distance between the points, C F, when measured around the arc pitch and across the chordial pitch. It follows that, the length, C D, equalling the arc pitch, we have by this construction obtained a chordial from an arc pitch.

When the diameter of a gear wheel is given, the measurement is that of the pitch circle; for example, a 10 inch gear is one whose pitch circle is 10 inches in diameter. It is a common practice, however, to give the size of the wheel by specifying the number and pitch of the teeth. In this case, if the arc pitch is given, the mechanic cannot readily measure the pitch accurately, especially is this the case with small pinions having coarse pitches; hence in selecting such a pinion pattern from the pattern loft, he will require to determine the chordial pitch before he can make the selection. If, on the other hand, the chordial pitch and the number of teeth employed to designate the sizes of gears, the diameters will not be exactly proportional to the number of teeth; for instance, a wheel with 20 teeth of 2 inch chordial pitch is not exactly half the diameter of one of 40 teeth and 2 inch chordial pitch, and for this reason it is preferable in using the pitch and number of teeth to denote the size to specify the arc pitch. Another reason is that the arc pitch is obtained by simply dividing the diameter of the pitch circle by the number of teeth, whereas to obtain the chordial pitch requires an abstruse calculation or a drawing, such as shown in Fig. 257.

As a remedy for these defects another and superior method of describing the sizes of gears is employed. It is by the employment of diametral pitch. The theory upon which this method is based is as follows: The diameter of the wheel at the pitch circle is supposed to be divided into as many parts as there are teeth in the wheel, then the length of one of these parts is the diametral pitch. The relationship which the diametral bears to the arc pitch is the same as the diameter to the circumference, hence a diametral pitch which measures 1 inch will accord with an arc pitch of 3·1416; and it becomes evident that, for all arc pitches of less than 3·1416 inches, the corresponding diametral pitch must be expressed in fractions of an inch, as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ and so on, increasing the denominator until the fraction becomes so small that an arc with which it accords is too fine to be of practical service. The numerators of these fractions being 1, in each case they are in practice discarded, the denominators only being used, so that, instead of saying diametral pitches of $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$, we say diametral pitches of 2, 3, or 4, meaning that there are 2, 3, or 4 teeth on the wheel for every inch in the diameter of the pitch circle.

Suppose now we are given a diametral pitch of 2. To obtain the corresponding arc pitch we divide 3·1416 (the relation of the circumference to the diameter) by 2 (the diametral pitch) and $3·1416 \div 2 = 1·57$ = the arc pitch in inches and decimal parts of an inch. The reason of this is plain, because, an arc pitch of 3·1416 inches being represented by a diametral pitch of 1, a diametral pitch of $\frac{1}{2}$ (or 2 as it is called) will be one half of 3·1416. The advantage of discarding the numerator is, then, that we avoid the use of fractions and are enabled to find any arc pitch from a given diametral pitch. Examples: Given a 5 diametral pitch; what is the arc pitch? First (using the full fraction $\frac{1}{5}$) we have $\frac{1}{5} \times 3·1416 = ·628$ = the arc pitch. Second (discarding the numerator), we have $3·1416 \div 5 = ·628$ = arc pitch. If we are given an arc pitch to find a corresponding diametral pitch we again simply divide 3·1416 by the given arc pitch. Example: What is the diametral pitch of a wheel whose arc pitch is $1\frac{1}{2}$ inches? Here $3·1416 \div 1·5 = 2·09$ = diametral pitch. The reason of this is also plain, for since the arc pitch is to the diametral pitch as the circumference is to the diameter we have: as 3·1416 is to 1, so is 1·5 to the required diametral pitch; then $3·1416 \times 1 \div 1·5 = 2·09$ = required diametral pitch.

To find the number of teeth contained in a wheel when the diameter and diametral pitch is given, multiply the diameter in inches by the diametral pitch. The product is the answer. Thus, how many teeth in a wheel 36 inches diameter and of 3 diametral pitch? Here $36 \times 3 = 108$ = the number of teeth sought. Or, per contra, a wheel of 36 inches diameter has 108 teeth. What is the diametral pitch? $108 \div 36 = 3$ = the diametral pitch. Thus it will be seen that, for determining the relative sizes of wheels, this system is excellent from its simplicity. It also possesses the advantage that, by adding two parts of the diametral pitch to the pitch diameter, the outside or total diameter of the wheel is obtained. For instance, a wheel containing 30 teeth of 10 pitch would be 3 inches diameter on the pitch circle and $3\frac{2}{10}$ outside or total diameter. Below is a table of circular and diametral pitches, which will be found very useful.

Diametral pitch.	Arc pitch.	Arc pitch.	Diametral
2	1·57	1·75 inch.	1·79
2·25	1·39	1·5 "	2·09
2·5	1·25	1·4375 "	2·18
2·75	1·14	1·375 "	2·28
3	1·04	1·3125 "	2·39
3·5	·890	1·25 "	2·51
4	·785	1·1875 "	2·65
5	·628	1·125 "	2·79
6	·523	1·0625 "	2·96
7	·448	1·0000 "	3·14
8	·392	0·9375 "	3·35
9	·350	0·875 "	3·59
10	·314	0·8125 "	3·86
11	·280	0·75 "	4·19
12	·261	0·6875 "	4·57
14	·224	0·625 "	5·03
16	·196	0·5625 "	5·58
18	·174	0·5 "	.6·28
20	·157	0·4375 "	7·18
22	·143	0·375 "	8·38
24	·130	0·3125 "	10·06
26	·120	0·25 "	12·56

In using diametral pitch to order wheels it is sufficient to employ two places of decimals; but where mathematical calculations are concerned it is better to use three places of decimals.

It is of but little value to give the size of a wheel to the practical workman or constructor in diametral pitch, because in laying out the wheel teeth he can only deal with either the arc or chordial pitch. He requires the diameter of the wheel and the number of teeth, and then by dividing off the pitch circle into as many equal divisions as there are to be teeth in the wheel, he obtains the arc and the chordial pitches. The length of the arc pitch he can ascertain by dividing the circumference of the pitch circle by the number of teeth, and the length of the chordial pitch he can measure by a standard lineal measuring rule. He has then to proportion the thickness of the tooth, the width of the space, and the height of the tooth, and in doing so the amount of clearance to be allowed must be taken into consideration. By clearance is meant the excess of the width of the space over the thickness of the tooth and the excess of the length of the tooth within the pitch line over its extension beyond the pitch line. The first is usually termed the clearance, and the second the clearance top and bottom. The use of clearances is to allow for imperfections in the workmanship, and is, therefore, made greater in wheels in which the teeth are cast than in those which are cut out by machinery, because wheels cannot be cast so accurately as they can be cut. A wheel moulded from a pattern cannot be so accurately cast as one moulded by a moulding machine, because the pattern is liable to warp, and requires to be well loosened in the mould to enable it to be drawn from the sand without drawing a portion of the sand up with it. When a moulding machine is used the section of pattern used is moved and extracted by mechanical means, and is lifted more truly vertical. By allowing clearance the tooth is proportionately weakened, hence in wheels whose teeth are cut but very little clearance is given, and in the case of involute teeth it is sometimes dispensed with altogether, or made so small as to merely prevent a tooth from contact with both sides of the space of the wheel to which it is geared. Top and bottom clearance is always made somewhat greater than clearance, either in involute or epicycloidal teeth. It follows, then, that the amount of clearance allowed is left largely to the judgment of the designer, and is made to suit the requirements of particular cases.

From the pitch of the teeth all the proportions of the teeth and spaces are designed, and for wheels that have cast teeth Professor Willis gives the following as the proportions generally adopted in practice: Depth from the point of the teeth to pitch line = $\frac{8}{10}$ of the pitch of the teeth; working depth = $\frac{8}{10}$ pitch; whole depth, $\frac{7}{10}$ pitch; thickness of tooth, $\frac{5}{11}$ pitch; breadth of space, $\frac{6}{11}$ pitch. To avoid the trouble of calculating these proportions for every required pitch we may construct a form of diagram which is usually termed a wheel scale, and which being made full size, in Fig. 259, will serve for all teeth up to 4 inches pitch. We first draw the line, A B, making it 4 inches long, and at a right angle to it the line, B C, whose length equals the whole depth of the tooth, which, according to Willis, is $\frac{7}{10}$ of the pitch; and as $\frac{7}{10}$ of 4 inches is $2\frac{8}{10}$, that is the length of B C. We then mark on B C the working depth of the tooth, that is $\frac{6}{10}$ pitch,

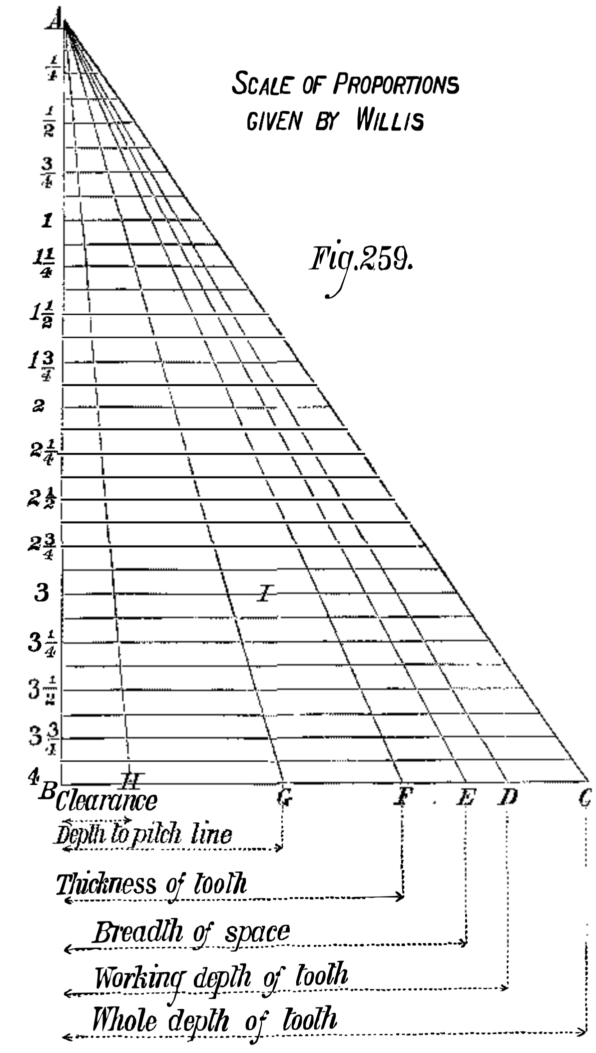

Fig. 259.

the distance from B D equalling $\frac{6}{10}$ of pitch. The breadth of space, B E, = $\frac{6}{11}$ pitch is next marked, and in the same way thickness of tooth, B F, = $\frac{5}{11}$ pitch. Depth to pitch line, B G, = $\frac{3}{10}$ pitch. For clearance top and bottom, $\frac{1}{10}$ pitch = B H is (according to Willis) allowed. From the points C, D, E, F, G, H draw lines meeting at A, and our scale is complete. Now it is evident that, by setting the compass points from B to H, D to G, B to F, B to E, B to D, and B to C, we obtain respectively the clearance, depth to pitch line, thickness of tooth, width of space, etc., etc., for a 4 inch pitch; for any other pitch we have only to take similar measurements on the horizontal line opposite the pitch marked on A B. Suppose then we have a wheel of 3 inch pitch; the full length of the line marked I is the whole depth of tooth, its length from its intersection with A B to its intersection with A D is the working depth of tooth, and so on. By using such a scale liability to error in making calculations is avoided, and furthermore exactitude is assured. Some of the terms given by Willis (whose proportions are almost universally accepted) are in elevenths of an inch, which divisions are not marked upon lineal measuring rules; hence by the trouble of making our correct scale, all future trouble as to these fractional parts of an inch is avoided. It is always best to mark the points C, D, E, F, G, H on the coarsest pitch on the scale, so as to obtain greater accuracy, and in doing so the elevenths of an inch may be obtained by spacing off an inch into eleven divisions, oil-stoning the compass points to make the fine adjustments.