Heating surface:
 Tubes.....1,554.8 sq. ft.
 Firebox.....118.3 " "
 Miscellaneous:
 Smokestack, height from rail to top.....15 ft.
 Capacity of tank.....4,422 gal.
 Capacity of coal space.....11,650 lb.

We are indebted to the Engineer for illustrations and particulars.

WORK DONE BY WHEELMAN AND PEDESTRIAN.

By H. K. LANDIS, E.M.

In the seances of the French and German medical societies the effect of cycling on general health is frequently discussed, and arguments advanced both pro and con. As they consist, however, in the exchange of individual opinions principally, and in conclusions arrived at from insufficient data, they will not be further touched upon. There is one exception, how-

which, of course, is equal to the resistance to motion. On this basis the calculations of M. Bouny were made, though he neglects giving any details whatever. Let us assume the length of crank of a standard machine to be 6.75 inches; this will produce a crank circle of 1.76 feet. The foot pounds expended per half revolution of crank, M. Bouny gives as 37.64. Let P = the average pressure; then $1.76 P = 2 \times 37.64$, or $P = 43$ lb. The average ordinate of knk' is JJ' , which must equal 43 lb.; with this scale we are able to give aa' , dd' , tt' and ww' their values in pounds. If we now construct upon the base line, zz' , the curves, xx' and vv' , the latter being the curve of muscular pressure, i. e., bb' less ee' , we will see that the difference represented by the shaded area, $vv'xx'$, will be lost work. As the average effective pressure under the given conditions was 43 lb., and the average muscular exertion, measured in pressure, was 126 lb. less 40 lb., or 86 lb., we see that

on hard inflated tires 8.4 ft. per half revolution of crank, which, according to M. Bouny, equals a work of 37.64 ft. lb.; or $8.4 T = 37.64$, from which $T = 4.47$ approximately as above, so that we know about under what conditions the test was made. For asphalt $f = 1.7$, and for country macadam $f = 8$. Using the data previously given, where the weight of rider was 113 and weight of wheel 23 pounds, and granting that for all velocities and persons half the power only is effective (an assumption not yet verified by experiment, though probably not far in error), we obtain the table below.

By an inspection of Fig. 3 we are able to appreciate how not only the effective but the waste work increases with values of f , for at 15 miles per hour we have attained an impossible exertion on sandy road. Various authorities say a day's work for a laborer is the exertion of 0.1 horse power for ten consecutive hours. This would bar out sandy road entirely and allow a speed

FIG. 1.—ANALYSIS OF PEDAL PRESSURE BY M. BOUNY.

a b = position of pedal; c d = relative intensity of pressure; c e = tangential component; d e = radial component.

ever, in the experiments ordered by l'Academie de Medecine, under the direction of M. Marey, and executed by M. Bouny, on the board track of the Velodrome d'Hiver, at Paris, and which have been described in the Comptes Rendus of the Academy of Sciences, June 15, 1896. Although the general results reported are not strictly in accordance with those of Jaquot, Guye, Barrow and others, yet there was a diagram presented which admits of more complete discussion than was given to it. The analysis of Fig. 1 is an amplification of this diagram, which was made at a velocity of 13 miles an hour, being the mean of five revolutions of the crank, by means of a pedal dynamometer registering both sliding and direct pressure on the pedal. These components were united, producing a resultant thrust, as cd , in position 4, Fig. 1. If we develop the crank circle, we will have the straight line, hh' , Fig. 2; upon this we will erect the ordinates of equal length to the successive darts or foot thrusts, which are limited by the curve, ff' , for the right foot, and curve, cc' , for the left foot. By adding these ordinates we obtain the curve, bb' , of the sum of pressures on both pedals. The weight of one leg of a 160 pound man is about 20 pounds; if we subtract this from the pressure of either foot, we obtain the muscular pressure alone, which, in this case, was never less than 10 pounds. By subtracting 40 pounds, ee' , from the ordinates of curve, bb' , we obtain the ordinates, for each successive position, representing the total muscular pressure on pedal. Referring now to Fig. 1, let us separate the thrusts, cd , into tangential (ce) and radial (de) components, the first being effective pressure producing rotation, while the latter simply means pressure on the crank shaft bearing. If we now use these as ordinates and erect on ll' , Fig. 2, we get the curves, ll' and kk' , for right and left crank, the ordinates below, ll' , representing negative tangential pressure, produced by unconscious back pedaling. Adding these pressures algebraically, we have a curve, knk' , to represent the effective tangential component of the total pressure, bb' . The shaded area, kl' , represents the effective work,

FIG. 2.—ANALYSIS OF FOOT PRESSURE ON PEDAL, BEING A DEVELOPMENT OF FIG. 1.

by a curious coincidence the effective pressure is just half the effort exerted by the rider.

In other words, a wheelman does just twice as much work as is necessary to drive the machine. It will be seen by curve, kk' , that there is no "dead center" and that the driving force is quite regular, at least more so than usually supposed. In Fig. 1 a decided backward pull is apparent in positions 6 and 7, which carries the other foot over the approximate "dead center" existing near position 14.

While making some experiments to verify the statements made by certain English engineers as to the traction and work necessary in bicycle propulsion, it was clearly demonstrated that existing data possessed agreement neither with the writer's results nor with any other contemporaneous experiments. It was therefore decided to develop an expression independently both in method and data, and the result were the following formulas:

$$T = 0.003 f W (1 + 0.01 V^2) + 0.005 V^2 A$$

$$H. P. = 0.0027 T V$$

T = traction — lb.
 W = weight of wheel and rider — lb.
 f = coefficient of roughness.
 V = velocity miles per hour.
 A = effective air surface — sq. ft.
 $H. P.$ = horse power.

In the preceding experiments $f = 1$; if we let in addition $W = 136$, $A = 4$, and $V = 13$, we will secure by this formula a value of T as 4.46. The machine used by the writer in the tests, a Columbia model 40, travels

TABLE I.—MUSCULAR EFFORT OF WHEELMAN.

V Miles per Hour.	Horse Power.			
	Effective.		Total.	
	$f=1.7$	$f=8$	$f=1.7$	$f=8$
1.....	0.002	0.009	0.004	0.018
2.....	0.004	0.017	0.008	0.034
3.....	0.007	0.029	0.014	0.058
4.....	0.012	0.044	0.024	0.088
5.....	0.018	0.058	0.036	0.106
6.....	0.027	0.080	0.054	0.160
7.....	0.038	0.108	0.076	0.216
8.....	0.052	0.134	0.104	0.268
9.....	0.069	0.175	0.138	0.350
10.....	0.092	0.223	0.184	0.446
11.....	0.113	0.270	0.226	0.540
12.....	0.147	0.333	0.294	0.666
13.....	0.185	0.409	0.370	0.818
14.....	0.228	0.498	0.456	0.996
15.....	0.272	0.580	0.544	1.160

on rough macadam of 5 miles and on asphalt of 8 miles per hour for ten hours. Zimmerman, in one of his best races, exerted 1.2 effective horse power while going at the rate of about a mile in 1.6 minutes, which we may

FIG. 3.—POWER EXERTED AND UTILIZED BY WHEELMAN—SHADED AREA REPRESENTS WASTED MUSCULAR EXERTION.

FIG. 4.—MUSCULAR FORCE EXERTED BY WHEELMAN AND PEDESTRIAN.
 B = curves for wheelman; P = curves for pedestrian; w = weight of either in pounds; $f = 1.7$ and 8 corresponds to asphalt and ordinary macadam roads.

regard as about the limit of speed and power of a wheelman. Therefore, 11 miles per hour is the limit of speed on sandy road, while on macadam road but one-fourth that power is required at the same speed, and but one-tenth on asphalt. Mendelsohn considers 37 miles per hour as excessive. M. Loewy, from experiments on a winding stairs, concludes that the exercise of 0.92 horse power was not fatiguing. This would mean total muscular exertion, and would mean a speed on macadam of 13 to 14 miles per hour. He however compares it to the work done by a cyclist going up a 3 per cent. grade at 11.8 miles per hour, in which he exerts but 0.32 horse power.

Let us now examine into the work done by a pedestrian. The act of walking consists of successively leaning forward and straightening up, accompanied by a push of the rear foot and a straightening of the forward leg. The muscular exertion here required is in the slight push alluded to, the lifting of the lower leg, and the raising of the entire body through the distance its center of gravity has fallen while leaning forward. We will designate

w = weight of pedestrian—lb.
 h = vertical fall and rise of body—inches.
 l = length of step—inches.
 V = velocity—miles per hour.
 A = air resistance surface—sq. ft.

Rigid accuracy must not be looked for in a discussion of this kind, owing to the extreme variability of factors due to the personal equation of the pedestrian; but we can deduce an expression showing relative values which will be sufficient for our purpose. Let us assume the average weight of lower leg as 0.17 w ; the foot to be raised 3 inches at beginning of return, or its center of gravity 1.5 inches. The foot pounds de-

veloped per step will therefore be $0.17 w \frac{h}{12} = 0.02 w$;

we can safely assume 0.75 lb. as the value for the forward push, or 0.005 w ft. lb., making a sum of 0.025 w .

At each step w is raised through $\frac{h}{12}$ feet exerting $w \frac{h}{12}$ ft. lb., which added to the other work gives us per step:

$$0.025 w + w \frac{h}{12} = w \left(\frac{h}{12} + 0.025 \right) = \frac{w}{12} (h + 0.3)$$

As $\frac{1}{12}$ is the length of one step in feet, there will be

$$\frac{5280}{12} = \frac{5280 \times 12}{1} \text{ steps per mile, or } \frac{5280 \times 12}{1} V \text{ steps}$$

per hour. Our expression then becomes: $\frac{w}{12} (h + 0.3)$

$$\frac{5280 \times 12}{1} V \text{ ft. lb. per hour, or } \frac{w}{12} (h + 0.3) 0.0027 V$$

horse power, after canceling and dividing by 60 $\times$ 33,000. As $H. P. = 0.0027 TV$, $T \frac{w}{12} = (h + 0.3) =$

equivalent traction. This last expression may seem somewhat nonsensical, but if a spring balance is attached to an average man, the pull necessary to cause him to walk, he being perfectly passive, will be found to agree pretty well with this formula. Its object is principally as an equivalent to bicycle traction. By comparing the two we see that while with the same person, bicycle traction depends upon f and V , equivalent pedestrian traction depends upon l and h . The former depends upon outside conditions, while the latter depends upon personal characteristics.

Air resistance is a small factor, but we will introduce it to make the expression complete. The United

States Coast Survey uses the expression $P = \frac{V^2}{200} A$

total pressure in pounds on A square feet area when the wind blows at V miles per hour. Suppose the air to be quiet, and the wheel to move at V miles per hour, we get the same result, which we must add to

traction, thus: $T = \frac{w}{12} (h + 0.3) + 0.005 V^2 A$, and then

$$H. P. = \left[\frac{w}{12} (h + 0.3) + 0.005 V^2 A \right] 0.0027 V.$$

Let us assume an average of $l = 26$ inches and $A = 6$ square feet. We can then calculate the horse power required at various velocities, assuming that h and l remain constant; this last assumption is not strictly accurate, but sufficiently so for our purpose, for as l increases h increases with it, and the ratio is probably not much affected.

TABLE II.—HORSE POWER EXERTED BY PEDESTRIAN.

V Velocity in Miles per Hour.	w = 156		w = 113	
	h = 0.8	h = 1.7	h = 0.8	h = 1.7
0.5	0.009	0.016	0.006	0.008
1.0	0.018	0.032	0.013	0.016
1.5	0.027	0.048	0.019	0.021
2.0	0.035	0.065	0.027	0.032
2.5	0.046	0.081	0.037	0.040
3.0	0.054	0.097	0.040	0.050
3.5	0.065	0.108	0.047	0.060
4.0	0.075	0.132	0.058	0.068
4.5	0.086	0.153	0.065	0.078
5.0	0.099	0.172	0.076	0.091
5.5	0.110	0.190	0.086	0.100
6.0	0.124	0.210	0.097	0.113
6.5	0.137	0.227	0.105	0.125
7.0	0.152	0.251	0.113	0.139
7.5	0.167	0.270	0.132	0.151
8.0	0.189	0.300	0.144	0.166

These results, along with those of Table I, are plotted as curves in Fig. 4.

If we take 4 miles per hour as the average speed of a pedestrian, the horse power he exerts is between 0.058 and 0.132. If the average speed of a wheelman were 10 miles per hour, he would exert a total effort of 0.184 to 0.446 horse power. Taking a mean value between these working extremes, we would have a ratio of effort of pedestrian to wheelman of approximately 1 to 3. If we compare the effort of a wheelman at 4 miles per hour, which is probably the lowest practical velocity, we find the ratio of effort of pedestrian to wheelman to be, at the same speed, about 2 to 1. Consequently, although a wheelman exerts three times as much effort in equal times at average speeds, a pedestrian exerts twice as much effort in traversing equal distances. Zuntz and Katzenstein give data which indicate that at 4 miles per hour a pedestrian develops 0.141 horse power; M. Loewy says 0.145 horse power for several hours; Smeaton states that the equivalent of a day's labor is at the rate of 0.114 horse power, which is probably not far from the effort exerted by an average man; walking for 10 hours would, therefore, constitute a day's work when 40 miles were traversed, while a bicycle would travel 80 miles when the wheelman was doing the same work.

By an inspection of Fig. 4 it will be seen what influence the variable factors have on the effort exerted between the limits of probable working extremes. A horse power is the exertion of 33,000 foot pounds per minute and must not be confounded with the power of a horse, which, according to Trautwine, is but 22,000 foot pounds per minute. From the table it is evident that the rate of increase in effort is greater with a pedestrian than a wheelman at the customary speed of each.

CHAMPAGNE.

ALTHOUGH, in considering wines, the crown may be awarded to Johannisberg for its spicy flower, to Tokay for its fine aroma, to Château-Yquem for its sweet fire, or to Malaga for its delightful richness, it is certain that champagne surpasses them all in popularity, reputation and the extent to which it is used. It has inspired the most brilliant songs of the poets, the fair sex is fond of it, it is, as the French say, "the wine of the king, and, therefore, the king of wines." But it has not enjoyed this high place of honor very long, although Brillat-Savarin, the celebrated epicure, states in his "Physiology of Taste" that champagne was first made in the fourteenth century, and in a few weeks was granted first place among wines. It became known at the banquets which King Charles VI, of France, gave in May, 1397, at Rheims, to the Roman Emperor and Wenzeslaus, King of Bohemia, who had come to make a treaty with him, and who were so pleased with the heretofore unknown wine that they and their followers made merry with it day after day for a month. But this fragmentary account stands so entirely unsupported that it is quite reasonable to set it down as apocryphal, a fable which one would gladly accept as a bright incident in serious history. Perhaps that tempting wine was a good vintage of ordinary wine without sparkle from the chalk cliffs of the Marne, for it is certain that bottles were seldom used until the eighteenth century, and corking was unknown; when the latter became necessary stoppers made of oiled hemp were used. The first use of the cork led to the discovery of champagne, and is ascribed to Don Pérignon, cellar master of the Abbey of Haute-Villers, who held his office between the years 1617 and 1715. In 1718 champagne was mentioned in print for the first time, with the remark that it had been known for twenty years. It was called "pétillant" (sparkling) and "cork driver," or "devil's wine." It was then believed that it was prepared by some mysterious method by the aid of sorcery, and only the bravest dared take this effervescent drink. This fear did not last long, however.

The secret of its manufacture was carefully guarded by the monks of Haute-Villers at first, but was discovered as soon as the use of glass bottles and corks for stoppers for the preservation of wine became general, for all young wine will generate carbonic acid when fermenting, and keeping it in this condition is simply a question of skill. Champagne is, therefore, a wine that depends on skill, and the pleasure that it gives is the best means of refuting the old theory, still held by a few in the wine regions, that a wine should be perfectly pure. Very few men have ever tasted absolutely pure wine; that is, wine made from the juice of one kind of grape.

The district in which champagne is manufactured is quite large, including nearly fifty thousand acres of vineyards, and the value of good land is remarkably high, \$15,000 per hectare (about two and one-half acres) is not uncommon. In Versy the average price ranges from about \$2,000 to \$5,700; in Epernay, Pierry and Haute-Villers, from about \$6,200 to \$8,100; and in Aize, \$1,900 to \$2,500 per hectare. The best grapes for making champagne are the "plante dorée," the Black Burgundy, the Pineau, Mennier, the Gros Blanc and Petit Blanc (white champagne grapes), and a few others. The vines have to be carefully tended, and every three years the bearing wood must be buried, so that the vines always appear young. Stakes are provided for the stems, all shoots without blossoms are cut off, and those that are left are not allowed to grow the full length of the stakes. There is no restriction on gathering grapes in Champagne; every one can harvest when and as he will. Champagne makers generally buy the grapes on the vine and then have their own people gather them carefully.

The wine is left in the storehouses until March, when the bottling begins. A large outlay is incurred in purchasing the bottles—which are always prepared during the previous summer—for single houses use as many as fifty thousand bottles, and many require no less than six hundred thousand per year. Each house keeps its own bottle tester, an experienced man, who can tell by the sound, when the sides of two bottles are struck together, whether they are perfect and strong enough for use or must be broken. The bottles are well washed with water, and then brushed out with alcohol and closed with old corks so that neither dust nor mould can get in. When the bottles have been filled they are taken to an "atelier," in which five men are at work, who finish twelve to fifteen hundred

bottles in a day, so that each minute two bottles pass through the hands of all five men. As the large houses send out several hundred thousand bottles per year, they, of course, have to erect several "ateliers" close together, so that this task can be completed within a month—a longer time is seldom allowed. Carefully selected corks must be used, and they cost from \$15.50 to \$19.50 per thousand. After the bottles have been corked they are placed in the fermentation storehouses, in stacks measuring from 16 ft. to 50 ft. in length by 3 ft. to 5 ft. in height, without supports or frames. They are arranged in layers two bottles deep, so that each bottle rests on a board pushed underneath, with its neck between the bottoms of two other bottles; the outer bottles are held firmly in place by wooden prisms. Such a wall of bottles is as firm as iron, but any bottle can be taken out without disturbing the others, and it is often necessary to remove separate bottles in order to ascertain whether the process of fermentation is progressing properly. As the heat of the season increases the wine begins to work, the carbonic acid expands and the empty space in the bottles disappears. Now comes the most critical period in the whole process of manufacture, when many of the bottles burst and the wine escapes.

If this loss does not exceed 8 per cent. in the month of August, the worst month, the manufacturer is satisfied; if it reaches 15 per cent., the wine must be cooled with ice or be stored in a cooler cellar; if it reaches 20 per cent., there is no remedy but to open the bottles.

Formerly many workmen were injured during these investigations and operations by the bursting of the bottles; so they are now provided with strong wire masks and leather clothing. At such times a champagne cellar resembles a battle field; there is an incessant cracking, splinters of glass fly to the ceiling or rattle on the floor, and there is the rushing of the flowing blood of the vine. Great damage is often done when the temperature rises suddenly and the necessary precautions have not been taken. During the months of September and October the wine gradually becomes quiet, and there is less and less breakage. The store or cellar is tightly paved and provided with outlet channels, by means of which the wine that has escaped from the bottles is collected in reservoirs for other purposes.

The operation that comes next in order is the removal of the sediment or deposit from the bottles. The bottles are unstacked, and each one is carefully examined; those that are found intact are thoroughly shaken, so that the sediment will be evenly distributed, and then they are placed mouth down in board frames provided with inclined apertures. The positions of the bottles are changed several times until they stand perpendicularly, with the mouths still down. The sediment that has collected on the corks is removed by disgorging. The bottles are carefully moved from the cellar to the "atelier," where the "degorgeur" stands with a tub in front of him, above which there is a barrel with a doorlike opening, in which stands a burning candle. The cork is loosened and flies with a report into the empty barrel, and the explosion also blows out the sediment; the man wipes off the mouth of the bottle quickly, corks it, and puts it aside. The work of disgorging requires skill, and is not without danger, because many of the bottles burst. The wine lost from the bottles during this process should not exceed 5 to 7 per cent. It is collected and used for making vinegar and cognac. Near the "degorgeur" sits the "opérateur," whose business it is to add the "liqueur." All champagne contains liqueur, which in very high grades consists only of a solution of rock candy made from sugar cane and the purest wine, and in ordinary grades, of sirup, wine and alcohol. Each manufacturer has his own way of making up his liqueur, which he keeps secret. The liqueur makes the wine stronger or milder, sharper or sweeter, according to the taste of the consumers. It is poured in either by means of a tin measure or of an ingenious machine, which puts exactly the same amount into each bottle without losing a drop. If the wine is to be colored, the coloring matter is added to the liqueur. The bottles are then filled up, by means of another machine, with clear, effervescing wine of the same quality, to which no liqueur has been added, whereby the loss of carbonic acid is made good. Next comes the corker, who inserts the corks—that have been prepared beforehand—by means of a machine; then the "ficeleur" ties them in with string, and finally they are wired with red hot wire. This completes the operations of the champagne manufacture.

The bottles are carefully washed, dried, and tested again as to their perfect clearness, and then the necks and corks are covered with tinfoil or wax, and the labels are pasted on. The principal houses do not use any label, being satisfied with the brand on the cork, which enjoys the protection of the law, so that imitation is extremely difficult in France, being punished with imprisonment and a high fine. Where a label is used, simple elegance is preferred to much decoration. The champagne bottles are next packed, after having been wrapped in paper, in boxes or baskets with straw.

In France, where champagne is used only with dessert, it is not liked either too strong or too sweet, the grades which foreigners consider inferior being preferred here. For Austria and Eastern Germany it is made specially sweet; and for Russia it is also made sweet and mild. England takes it with the least liqueur, for there a strong tasting wine with considerable body is liked best. There are three grades of champagne: the crémant, mousseur, and grand mousseur. The first, the crémant, is the lightest, having the least foam, only what resembles a light cream, hence its name; the mousseur is more effervescent, and runs over the mouth of the bottle when the cork is drawn; the grand mousseur projects the cork with a loud report and foams in the glass. Experiments with the manometer show that the mousseur must have a pressure from four to four and one-half atmospheres and the grand mousseur from four and one-half to five; wine that has a pressure of less than four atmospheres is classed as crémant. The pressure cannot be greater than six atmospheres, for if it reaches seven or eight atmospheres, the bottle bursts. A distinction is generally made between ordinary wine, which formerly went under the name of "sillery mousseux," and "grand vin" or "qualité supérieure," "vin royal," "impérial," "fleur" or "qualité exquise."

Champagne is given a light rose tint by means of