side in passing through the distance s is $v/2$, and the time is $s \div v/2 = 2s/v$, the same as in the first case. Which proves the proposition.

Since from (1) we have $3PV = \frac{1}{2} M\bar{v}^2$ or $\frac{3}{2} PV = \frac{1}{4} M\bar{v}^2$, we may substitute this value in the virial equation, and remembering that $\Sigma \frac{1}{2} m\bar{v}^2 = \frac{1}{4} M\bar{v}^2$, we get $-\frac{1}{2} \Sigma Rr = -\frac{1}{4} M\bar{v}^2$. Hence also

$$P = \frac{1}{3} \rho \bar{v}^2 \dots \dots \dots (2)$$

where $\rho = \frac{M}{V}$ the density. The above equation is easily obtainable without the use of the virial equation *when the time of impact* is taken into consideration. A phenomenon which cannot be assumed to be instantaneous without upsetting the dynamical definition of the measurement of a force; which expressed algebraically is $Ft = Mv$. From which it is evident that when t the time is 0, v the velocity, is also 0.

When the virial equation is made applicable to the case of a gas composed of molecules capable of vibrating, it seems obvious that the term $\Sigma \frac{1}{2} m\bar{v}^2$ should be written $\Sigma \frac{1}{2} \beta m\bar{v}^2$; because, as shown by Clausius, the internal energy of the molecules bears a constant ratio to the energy of agitation. We must look to the *mechanical structure of the molecule* for the reason of this. Here the fact is simply accepted, not explained; but it is obvious that the same forces which impart translatory energy to a molecule will impart vibratory energy also. The same reasoning applies to the term $-\frac{1}{2} \Sigma Rr$, which now becomes $-\Sigma \beta(Rr)$. The volume of the gas is unaltered by the vibrations, and the pressure is dependent on the two other terms. Hence the equation may be written

$$\frac{3}{2} PV = \Sigma \frac{1}{2} \beta m\bar{v}^2 - \frac{1}{2} \Sigma \beta(Rr) \dots \dots \dots (3)$$

And from this we get

$$P = \frac{1}{3} \beta \rho \bar{v}^2 \dots \dots \dots (4)$$

The above equation may be written

$$P_i = \frac{1}{3} \rho \bar{v}_i^2; \dots \dots \dots (5)$$

Where $\bar{v}_i = \beta \bar{v}$. Again equation (2) may be written

$$P_i = \frac{1}{3} \rho \bar{v}_i^2; \dots \dots \dots (6)$$

the suffix i denoting that the pressure, density, and mean square velocity are those of an ideal gas composed of smooth elastic spheres.

If P_i , ρ_i , and $\bar{v}_i$ in (6) are taken respectively equal to P , ρ , and $\bar{v}_i$ in (5); then it is evident that $\bar{v}_i$ in (5) is the velocity of mean square of an ideal gas which, having the same density, would give the same pressure as a natural gas. Hence $\bar{v}_i$ can be found from (6). Now the total energy in unit mass of a gas is given by the equation

$$K_v T = \frac{1}{2} \beta \bar{v}^2; \dots \dots \dots (7)$$

where K_v is the specific heat at constant volume, and T is the absolute temperature. From which equation $\bar{v} \sqrt{\beta}$ can be found. We have also from above

$$\bar{v} \beta = \bar{v}_i \dots \sqrt{\beta} = \frac{\bar{v}_i}{\bar{v} \sqrt{\beta}} \dots \dots \dots (8)$$

from which equation the value of $\sqrt{\beta}$ and consequently β can be found.

The equation $\beta = 3k(\gamma - 1)$ can now be proved as follows. Multiplying both sides of (4) by V , the volume of unit mass, and combining with (7), we get

$$K_v T = 3PV \dots \dots \dots (9)$$

Now from (5) and (6), taking $\rho = \rho_i$ we get $P = P_i/\beta$, and substituting in (9) $K_v = 3P_i V/\beta T$. But $P_i V/T = K_{ip} - K_{iv}$; or the difference between the specific heats at constant pressure and constant volume; the suffix i indicating, as before, that the symbols refer to an ideal gas. Hence

$$\beta = \frac{3(K_{ip} - K_{iv})}{K_v} = \frac{3k(K_p - K_v)}{K_v} = 3k(\gamma - 1) \dots (10)$$

Here k is some factor which for so-called permanent gases is very nearly unity. For such gases we may write (10)

$$\beta = 3(\gamma - 1); \text{ or } \gamma = \frac{1}{3}(\beta + 3) \dots \dots \dots (11)$$

In the following table the values of β , except in the case of argon, are calculated from equation (8); and $\bar{v}_i$, the velocity of ideal gases having the same pressure and density as their cor-

responding natural gases, at standard temperature and pressure, from (6). The velocities are given in feet per second, and the value of gravity is taken at 32.2. Column (4) gives the values of γ for the different gases calculated from equation (11); and column (5) gives the experimental values of γ . The close agreement between these values is a significant fact.

(1)	(2)	(3)	(4)	(5)	(6)
β	$\bar{v}_i$	$\bar{v}$	$\gamma = \frac{1}{3}(\beta + 3)$	γ Ex-periment	k
Hydrogen ... 1'234 ... 8551 ... 6925 ... 1'4115 ... 1'412 ... 1'00035					
Oxygen ... 1'197 ... 2140 ... 1787 ... 1'399 ... 1'402 ... 1'0021					
Nitrogen ... 1'227 ... 2282 ... 1860 ... 1'409 ... 1'411 ... 1'0014					
Dry air ... 1'222 ... 2250 ... 1841 ... 1'407 ... 1'409 ... 1'0014					
Argon ... 2 (about) ... 1940 ... 970 ... 1'7 ... 1'7 ...					

8, Norfolk Square, W., June 13.

C. E. BASEVI.

Romano-British Land Surface.—Flint Flakes Replaced.

IN the early spring of the present year, whilst passing a newly-opened excavation near Caddington Church, three miles south-east of Dunstable, I noticed a very thin horizontal line of sharp flint flakes, embedded a foot deep from the surface-line of an old pasture. I could see at once that the line represented an old living surface, so I took a few of the flints away. In removing the stones from the soil, one or two little fragments of Romano-British pottery came away with them. The flakes were lustrous,

FIG. 1.—Fragment of perforated Romano-British pottery (half actual size).

chiefly black and brown-grey, and as sharp as when first struck. On looking over the flints in the evening, I was able to replace five on to each other. This fact, and the occurrence of the pottery fragments, proved the old surface to have remained intact from Romano-British times.

A little later in the spring, about six square yards of the super-incumbent soil were carefully removed for me, when other flakes were found *in situ* to the exact number of four hundred; with these were eighteen fragments of Romano-British pottery, one piece—somewhat like the bottom of a pot—perforated, as here

FIG. 2.—Four conjoined flint-flakes (half actual size).

illustrated. Amongst the flints were two cores, two hammer-stones, three scrapers, part of one edge of a chipped celt, and several neatly chipped but apparently unfinished little implements. A middle-brass Roman coin, too corroded for identification, was found on the same surface in a second excavation close by; with this was a small piece of wood carved to represent a horse's fore-leg, and a well-finished and perfect unpolished flint celt.

In sorting the flints I was able to replace thirty-eight on to each other in groups of from two to five. Two of these groups

are here illustrated—one a group of four, the other of two; the latter shows a straight-edged scraper above, conjoined to a simple flake below.

Hertfordshire conglomerate occurs as a surface stone at the same place, and I have at different times picked up very thin pieces without bulbs which appeared to me to have been artificially flaked. I have, however, kept no disputable objects. Hertfordshire "plum-pudding stone" was certainly flaked by the Kelts of this district, as is proved by the large, faceted and well-bulbed knife-like flake of conglomerate, found by myself at Caddington, here illustrated. This stone is not mentioned as one

FIG. 3.—Straight edged scraper, conjoined to a flake (half actual size).

known to have been utilised for tools in the list given by Sir John Evans, in his "Stone Implements of Great Britain."

It is difficult to fix a date for the Romano-British living surface here mentioned, as the coin is too corroded for determination; but a correspondent, the Rev. Henry Cobbe, of Maulden, has a Roman coin, found in an adjoining field at Caddington, inscribed "C. CÆSAR AUG. GERMANICUS." If this inscription indicates the Emperor Caligula, as Mr. Cobbe believes, we have a date, A.D. 37-41, and the coin was probably brought over by one of the

FIG. 4.—Large knife-like flake of Hertfordshire conglomerate (half actual size).

soldiers of Aulus Plautius under Claudius, in the second coming of the Romans in A.D. 43.

A short distance from the old land surface here described is an extensive Roman refuse pit with abundant broken pottery; so that it is safe to assume that a Roman villa once stood close by, and we seem to have evidence of the curious fact of a Kelt sitting down in close proximity to a Roman house and its refuse pit, quietly chipping his stone implements. It is equally curious that the implements and detached flakes have remained undisturbed so near the surface for nearly two thousand years.

Dunstable.

WORTHINGTON G. SMITH.

The Bifilar Pendulum at the Royal Observatory, Edinburgh.

SOME interesting readings of the bifilar pendulum, designed by Mr. Horace Darwin for measuring movements in the earth's surface, were made here at noon on the 9th inst. This instru-

ment, which indicates oscillations in a north and south direction, was erected in March of last year, and daily observation of it has since been carried on, the scale being read off each minute, from five minutes before to five minutes after Paris noon. On the 9th inst. nothing unusual was noticed during the first seven readings, these being all practically the same; but on putting my eye to the telescope for the eighth, I at once noticed that during the interval of less than a minute since the preceding reading, the mirror had rotated considerably about its vertical axis, the normal having moved towards the north, the difference between the seventh and eighth readings being no less than 7.6 mm. of the scale. An immediate examination of the lamp-stand showed it to be perfectly firm. After the regular daily readings were completed, others were made at intervals of generally two minutes, for half an hour after Paris noon. These showed two quite conspicuous oscillations of the mirror during its return to its original position, which it reached about thirteen minutes after noon. It continued to move beyond this point towards the south, till at oh, 31m. Paris mean time it was 4.1 mm. south of the point at which the scale was first read off. Later readings in the course of the day showed that it was still moving slowly to the south, but no further oscillations were recorded. In the evening, when the mirror appeared to have come to rest, the sensitiveness of the instrument was tested, and with this the column headed "Tilt of mirror-frame" in the following table has been computed. The positive sign indicates a tilt to the north.

	Paris mean time.		Scale reading of ray from mirror.	Tilt of mirror-frame in preceding minute.
	h.	m.	mm.	
June 8 . .	23	55	284.2	
		56	4.1	-0.005
		57	4.1	0.000
		58	4.0	-0.005
		59	4.0	0.000
June 9 . .	0	0	4.2	+0.010
		1	284.4	+0.010
		2	292.0	+0.385
		3	2.1	+0.005
		4	1.6	-0.025
		5	2.3	+0.035
		6	2.1	-0.010
		8	290.2	-0.096
		10	288.7	-0.076
		12	7.0	-0.086
		14	5.4	-0.081
		16	2.8	-0.132
		18	2.1	-0.035
		19	2.8	+0.035
		21	1.4	-0.071
		23	0.3	-0.056
		25	1.7	+0.071
		27	1.3	-0.020
	0	31	280.1	-0.061

THOMAS HEATH.

Royal Observatory, Calton Hill, Edinburgh, June 20.

Migration of a Water-beetle.

LAST night, at about ten o'clock, a beetle flew in through the open window, alighting on a bowl of roses in the centre of the dining table. On being dropped into a finger-bowl he promptly dived and swam merrily, and proved to be a specimen of the ordinary brown water-beetle, to be found in every pond or ditch of water. Now the nearest water to my dining-room window is the Thames, distant over a quarter of a mile as the crow flies, whence this water-beetle must have flown. Can any of your readers inform me whether such long flights have been observed before in connection with the pairing season or migration of this species? I enclose you a rough sketch of the beetle, not knowing its specific title amongst the Coleoptera.

ROSE HAIG THOMAS.

Basildon, Reading, June 23.