1899

Some Experiments in Molecular Contact

James S. Stevens

SOME EXPERIMENTS IN MOLECULAR CONTACT.

By James S. Stevens.

In working with an interferometer it was observed that one could slide the brass plate which carries the movable mirror along the bed upon which it lies so that the fringes would suffer displacement for a small but definite amount, and that when the plate was released they would return to their original position. The idea occurred to me that it might be possible to measure these displacements for given weights applied to move the mirror-plate, and ascertain if they followed any law, and what relation these experiments bore to the ordinary experiments for finding the coefficients of friction.

For this purpose I had constructed four plates — of brass, copper, steel and cast iron, — whose dimensions were $8 \times 5 \times 1$ cm. One side and one edge of each were smoothly polished so that the friction was reduced to a minimum. The following table shows the weights, loads and coefficients of friction of repose for each case :

Table I.

Coefficients of friction—Ordinary method.

Arrangement.	Weight of plate moved.	Load.	Coefficient.	Coefficient for edge.
Copper on brass	272.7g	60.1g	0.22	0.21
Brass on copper	255.0	52.0	0.20	0.17
Steel on iron	241.0	61.0	0.25	0.19
Iron on steel	220.5	37.0	0.16	0.14
Copper on steel	232.7	46.0	0.19	0.25
Copper on iron	232.7	41.0	0.17	0.17
Brass on steel	255.0	41.0	0.16	0.27
Brass on iron	255.0	37.0	0.15	0.18
Steel on copper	241.0	46.0	0.19	0.18
Iron on copper	220.5	42.5	0.19	0.18
Steel on brass	241.0	31.0	0.13	0.18
Iron on brass	220.5	36.0	0.16	0.12

These determinations were made chiefly for reference and were probably in error by as much as two per cent. The apparent inconsistencies may be explained by inequalities in polish.

The next step was to fasten the moving mirror, *D*, with wax on one end of the upper plate, *A*, — the one to be tested, and then find the fringes. In the end of the plate opposite from the mirror were inserted two screw hooks and to these was fastened a scale

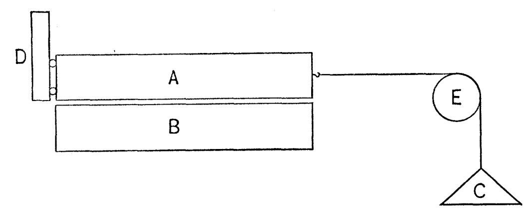

Fig. 1.

pan, *C*, by means of the cord passing over the pulley *E*. The cord and pulley weighed 6 g. and the mirror 5.9 g. Weights were placed in the pan and the resulting displacements of the fringes observed.

The table below contains the results of the various tests :

TABLE II.

Measurements by displacement of fringes.

Load.	Copper on Brass.	Brass on Copper.	Steel on Iron.	Iron on Steel.	Copper on Steel.	Copper on Iron.
11g	0.00λ	0.00λ	0.00λ	0.03λ	0.03λ	0.00λ
16	0.03	0.00	0.03	0.08	0.04	0.03
26	0.05	0.05	0.08	0.10	0.06	0.09
36	0.10	0.08	0.10	0.15	0.11	0.11
46	0.10	0.08	*	*	0.13	0.15
56	*	*			*	0.18
66						*
Load.	**Brass on Steel.**	**Brass on Iron.**	**Steel on Copper.**	**Iron on Copper.**	**Steel on Brass.**	**Iron on Brass.**
11g	0.00λ	0.00λ	0.03λ	0.00λ	0.00λ	0.03λ
16	0.05	0.03	0.05	0.03	0.03	0.05
26	0.08	0.08	0.08	0.08	0.05	0.08
36	0.10	0.13	*	0.10	0.08	0.10
46	0.13	*		*	0.10	0.13
56	*				0.13	*
66					*	

Table III. shows the results of two experiments with the plate on its edge ; Table IV. where the rough surfaces of copper and brass were used; Table V. where an additional weight of 235.1 g. was placed on the brass plate while it moved on the copper; in Table VI. steel was moved on steel, first on its side and then on its edge.

Table III.

Plates on Edge.

Load.	Copper on Brass.	Steel on Iron.	Load.	Copper on Brass.	Steel on Iron.
11g	0.00λ	0.00λ	36g	0.13λ	0.08λ
16	0.03	0.03	46	*	0.13
26	0.08	0.05	56		*

Table IV.

Rough Sides.

Load.	Copper on Brass.	Load.	Copper on Brass.
16g	0.00λ	56g	0.08λ
26	0.03	76	0.23
36	0.05	96	*

Table V.

Weight added (235.1g).

Load.	Brass on Copper.	Load.	Brass on Copper.
16g	0.03λ	46g	0.10λ
26	0.05	56	0.15
36	0.10		

Table VI.

Steel on Steel.

Load.	On Side.	On Edge.	Load.	On Side.	On Edge.
11g	0.00λ	0.00λ	46	0.15λ	0.15λ
16	0.03	0.03	56	0.15	*
26	0.05	0.05	66	0.20	
36	0.10	0.10	76	0.25	
			86	*	

Coefficient by ordinary method 0.23.

An inspection of these tables shows that in most cases 11 g. and in every case 16 g. was sufficient to cause motion in the upper plate. In every case except those marked * the fringes returned to their original position when the weight was removed.

The accompanying plots are based upon the data in Table II. They are approximately straight lines and departures therefrom would seem to be due to inaccuracies in reading and inability to make readings for loads differing by less than 5 g. The motion of the fringes was measured with reference to a vertical wire placed in

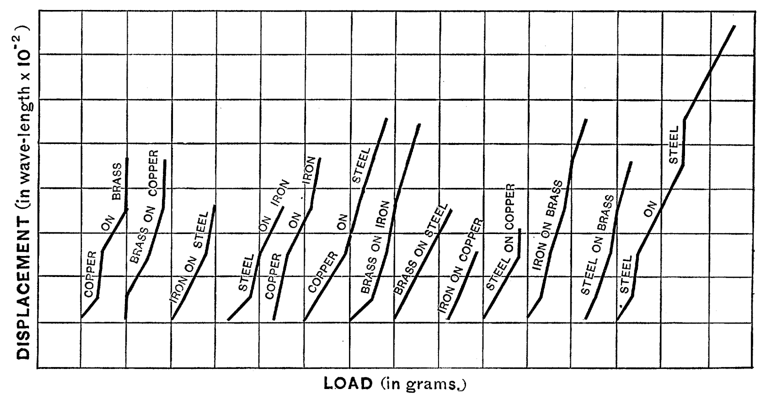

Fig. 2.

front of the moving mirror. Motions through a dark or yellow space (sodium light being used as a source) is equivalent to 0.25 wave-lengths. By various methods this motion may be read accurately to tenths of a space or 0.025 of a wave-length. In each case the number set down in the table represents a mean of several trials so that it is safe to estimate that the readings are not in error by more than 0.01λ. Probably the error is less than this quantity.

In conclusion it may be said:

1. When a proper force is applied there is a motion of one surface over another which takes place before the body actually begins to slide.

2. This motion, unlike that produced when friction is overcome, is imperceptible under ordinary conditions, and the plate returns to its first position when the force is removed.

3. These minute distances passed over by the plate are nearly (probably exactly) proportional to the force applied to produce the motion.

4. This law seems to hold for the case where a plate slides on its

edge, for rough surfaces as well as smooth, for dissimilar surfaces as well as similar, and when an extra weight is placed on the moving plate.

5. As a possible explanation it is suggested that when a force is applied which is not sufficient to produce a complete rupture between the molecules in contact, there is introduced an additional stress which pulls them into their ordinary position when its cause (the force applied) is removed.

Physical Laboratory, University of Maine.