

oil with the tungate drier (panel No. 52) produced such good results.

Mr. TOCH agreed that the thickness of the coating was in direct ratio to its protective quality, provided it had a protective quality to start with, and assuming, of course, that it was a drying oil. He had not made any measurements of the thickness of the various films, but those that gave good results showed an appreciable thickness of film.

Prof. A. H. SABIN said that a shop coat of linseed oil for bridge work had not entirely gone out of use. There were several different reasons for applying it. The structural metal, as received from the shop, was covered with mill scale. Sooner or later it would come off, carrying with it any paint that had been applied. The shop coat of linseed oil was applied, and the bridge erected; the mill scale was allowed to rust off, and then the bridge was thoroughly cleaned and painted. On another railroad a shop coat of linseed oil was applied, the bridge erected and then painted by the company's painters. Others held that a shop coat of linseed oil enabled the inspector to see whether the rivetting, etc., had been properly done, better than when the work had been painted. The question was whether it was possible to get a vehicle that would work more easily than linseed oil and could be sold at a suitable price.

Mr. STEVENSON said that in the erection of steel the shop coat was almost always torn off in the rough handling it received. It cost more to apply a coat of paint in the shop than it did in the field. Linseed oil gave protection for four or five months, and that was as long as was necessary, and had given very good results except in one or two cases.

(see this Journal, 1915, 62—65), I pointed out that when considering the indications given by such an instrument as the Cloth Oil Tester it should be remembered that one was dealing with the oil in very intimate contact with cotton wool, and that probably the action between the oil and the cotton had something to do with the result. I suggested experiments in which the oil should be spread on some inert substance such as glass wool.

Subsequently Mr. Miller, my assistant, pointed out that experiments had already been made on these lines, and looking back over the laboratory note-books we found that some work had been done in 1895—96. These experiments are now described, together with some experiments made since the meeting already referred to; and they do not bear out the opinion I then expressed. At any rate the heating proceeds rather more rapidly when slag or glass wool is used instead of cotton wool (see Tables 1 and 2).

Tables 3 and 4 deal with oils tested in the usual way in the Oil Tester—that is, spread on cotton wool—and are given to show that the iodine value alone does not give reliable indication as to the behaviour of an oil as regards liability to induce spontaneous heating when spread on fibre.

Table 3 gives the results of experiments on hardened cottonseed oil (samples kindly given by Dr. Armstrong, of Messrs. Joseph Crossfield & Sons, Ltd., Warrington), and are of some interest apart from the question of iodine value, etc.

It will be noted in the case of the "semi-hardened" oil that the free fatty acids "cracked out" and dried (containing any unsaponifiable matter present) give a decided rise of temperature in the Oil Tester, whilst the oil does not; the point of interest is that the iodine value of the free fatty acids is not substantially higher than that of the neutral oil. It will be noted further that the free fatty acids from the cottonseed oil "hardened nearly to saturation" (as described by Dr. Armstrong) do not give any rise of temperature. The iodine value of these was found to be 2.5 (determined by Dr. Ingle). The neutral oil itself was not tested in the Oil Tester, it being presumed to give no rise in temperature.

In Table 4 we have two oleines of similar composition as regards unsaponifiable matter and free fatty acids, and similar iodine value, showing a decided difference in behaviour in the Oil Tester—A (iodine value 81.8) giving no rise, B (iodine value 87.5) showing a very rapid rise, being evidently a distinctly dangerous oil as regards liability to induce spontaneous heating when spread on fibre.

Yorkshire Section.

Meeting held at Leeds, on Monday, April 19th, 1915.

MR. F. W. RICHARDSON IN THE CHAIR.

NOTE ON THE BEHAVIOUR OF SOME OILS AND FATTY ACIDS IN MACKEY'S CLOTH OIL TESTER.

BY WILLIAM MCD. MACKEY.

In the discussion on the paper by Hyland and Lloyd, "The Oxidation of Oils and Fatty Acids"

TABLE 1.

		1h. 0m.	1h. 15m.	1h. 30m.	2h. 0m.	Maximum	h. m.
Same sample	Olive oil on cotton wool	95° C.	—	99° C.	103° C.	105° C. in	3 0
	" " wool	92.2° C.	98° C.	101.7° C.	105° C.	109.8° C. "	4 45
	" " slag wool	101.5° C.	104° C.	105.8° C.	109° C.	111° C. "	3 50
	" " cotton wool	96.5° C.	98.5° C.	100° C.	104° C.	Experiment stopped	
Same sample	" " glass wool	102° C.	108° C.	115.5° C.	—	129° C. in	1 55

TABLE 2.

	1h. 0m.	hrs. min.	
Same sample	Raw linseed oil on cotton wool, typical of a number of experiments	110° C.	200° C. in 1 11
	Raw linseed oil on slag wool	—	200° C. " 0 43
	Boiled linseed oil on slag wool	—	200° C. " 0 28
	Cottonseed oil on cotton wool	110° C.	200° C. " 1 10
	" " slag wool	173° C.	191° C. " 1 10
			Thermometer withdrawn
			" " "
			" " "
			Temperature began to fall after 1 hour 15 min.

NOTE.—In the case of the slag wool 32 grms. was used and in that of the glass wool 28 grms.

TABLE 3.

	1h. 0m.	1h. 15m.	1h. 30m.	2h. 0m.	
Semi-hardened cottonseed oil on cotton wool, iodine value 77.6	95.2° C.	96° C.	96.8° C.	97.2	Experiment stopped
Fatty acids from above sample on cotton wool, iodine value 79.4	111.3° C.	118° C.	—	—	202° C. in 1 hour 24 min. Thermometer withdrawn
Fatty acids from hardened cottonseed oil on cotton wool ("hardened nearly to saturation")	93.5° C.	95.3° C.	96° C.	96° C.	Experiment stopped

TABLE 4.

	1h. 0m.	1h. 15m.	1h. 30m.	2h. 0m.	2h. 15m.	
Oleine "A" on cotton wool, iodine value 81.8	95° C.	96° C.	96.8° C.	97.6° C.	98.8	Experiment stopped
Oleine "B" on cotton wool (similar to above as regards unsaponifiable and free fatty acids) iodine value 87.5 ..	107° C.	222° C.	Thermometer withdrawn			

DISCUSSION.

Mr. F. W. RICHARDSON said that the iodine value of an oil was apparently not so reliable a factor as he had thought in regard to oxidation. In his opinion it was a question whether oxidation under ordinary conditions was comparable with oil tested in the Cloth Oil Tester. His experience was that, all things being equal, the iodine value indicated fairly well the increase of viscosity and the oxidation changes which would take place when an oil was exposed at the ordinary temperature.

Dr. H. INGLE said that Mr. Mackey's results proved that the heating of oils in the Tester, and presumably on the wool, etc., depended upon the surface of oil exposed to the air and not upon any action of the oil upon the fibre. It would be interesting to compare these surfaces of cottonwool, wool, and glass wool, but it was clear that the animal and vegetable fibres might absorb oil into their mass and so reduce the surface layer of the oil exposed. That would explain why in some cases a greater rise in temperature was recorded upon glass wool than on cotton wool, since glass wool was impervious to oil.

The experiments with boiled linseed oil showed the effect of a drier increasing the rate at which the oil would absorb oxygen. The rise in temperature in all cases must depend upon the rate of the oxidation, and the experiment with boiled linseed oil illustrated that point admirably. The iodine value (which, taking all in all, was one of the best tests) only gave the amount of oxygen that might be absorbed, not the rate at which it would happen. He (the speaker) had shown that the acids of linseed oil took over twenty months to dry (this Journal, 1913, p. 639), while the glycerides would dry in a few days, although the iodine value of the acids was higher than that of the glyceride. The same applied to the ethyl esters, as had been shown by himself and also by Dr. Lloyd. However, the actual amount of oxygen absorbed by the acids and ethyl esters was only half that absorbed by the glycerides.

It was the rate of oxidation which determined the rise in temperature, for even if the actual oxygen absorption, measured by direct weighing or by the iodine value, were great, if the rate of absorption were slow, the heat generated was dissipated and no great rise in temperature resulted.

Reverting to the differences in the results which Mr. Mackey had obtained with the free acids and their glycerides, great difficulty was found in explaining this. One suggestion he (the speaker) offered was that decomposition of the peroxide of an acid (at the temperature of the tester) by the formation of alcoholic or aldehydic groups in the

presence of the free acid might give lactones, while these could not be formed from the glycerides. Whether the formation of lactones would give rise to sufficient heat to cause the marked increase in temperature noted by Mr. Mackey was doubtful. Water would aid in the decomposition of the peroxides and the formation of hydroxyl groups, and it had been shown by both Mackey and Lloyd (this Journal, 1915, p. 62) that moisture increased the heat developed in the tester.

He did not think that any appreciable polymerisation of ordinary oils took place below 500° F.

Mr. W. RUSHBY said that when slag wool was used in the Tester, no moisture was present, but if wool or cotton wool were used moisture would be present during the testing, because moisture was naturally present in wool up to 15% and cotton up to 8%.

Mr. RICHARDSON said that his experiments bore out Dr. Ingle's statement. If a level surface were used, the oxidation was proportional to the area of the surface. That was the reason slag wool gave higher results than either wool or cotton wool.

Dr. L. L. LLOYD said that he had carried out some experiments similar to those of Mr. Mackey's. The materials were all thoroughly scoured with benzene, water, and a little potash soap made from stearic acid, then washed with water and air-dried. The method of mixing with the oils and the compactness of the oiled material were approximately similar. The results are given in the following table:—

Oil.	Fibre material.	Max. temp.	Time for max. temp.	Decrease in iodine value.
Olive I.v. 86.8	Glass wool	190° C.	5h. 45m.	37.2
	Cotton "	190° C.	5 40	30.0
	Wool "	195° C.	6 15	43.6
	Silk	185° C.	6 30	35.1
Cotton seed I.v. 108.7	Glass wool	200° C.	1 15	36.8
	Cotton "	210° C.	1 15	35.2
	Wool "	203° C.	1 20	40.8
	Silk	196° C.	1 15	37.1
Cotton seed hydrogenated I.v. 35.0	Glass wool	96.3° C.	5 30	3.2
	Cotton "	95.8° C.	5 30	1.8
	Wool "	97.3° C.	5 30	1.8
	Silk	96.1° C.	5 30	1.6
Olefin 70% I.v. 83.2	Glass wool	98.2° C.	5 30	7.0
	Cotton "	96.5° C.	5 30	6.0
	Wool "	97.3° C.	5 30	7.3
	Silk	96.8° C.	5 30	6.0

The product extracted from the wool containing the olive oil, after heating in the Mackey Tester, was very dark and was found to contain sulphur, which was no doubt obtained by the decomposition

of the wool. Similarly the cottonseed oil product extracted from the wool also contained sulphur.

From the above figures it appeared that the nature of the material upon which the oil was spread was of little consequence as regards oxidation. It was, however, different where oxidisable oils were exposed, when heating effects took place, because wool, silk, and inert materials did not fire, but cotton fired and burned fairly easily, the cotton charring at about 180° upwards.

Olive oil exposed to the oxidising action of air, when treated in the Mackey Tester, did not show any appreciable heating effect. The oil, however, became oxidised, and after extraction had decreased in iodine value; the oil was also somewhat thicker. If, however, the material were left in the Mackey Tester for about 4 to 5 hours, then the heat produced by oxidation or other causes became apparent and the rise in temperature took place quickly. If olive oil were exposed to the air at ordinary temperature, the absorption of oxygen took place so slowly, that after three years' exposure, in a thin film, the iodine value was reduced only by about 4 to 5%. That the iodine value did not govern the liability to oxidation and firing was proved from the following experiments in the Mackey Tester. Fatty acids of iodine value 77.8 registered 99.5° C. after five hours' treatment in the Tester, ethyl oleate (pure) of iodine value 75.6 registered 213° C. in five and a half hours, the ethyl oleate rising at first extremely slowly and finally very rapidly.

Mr. J. HYLAND, referring to the paper of Hyland and Lloyd, said that by oxidising oils on quartz at 50° C., until a maximum gain in weight was reached, a decrease in iodine value resulted very similar to that found after the oil had been through the Mackey Tester. Ethyl oleate gave a decrease in the tube of 31.4 and in the Mackey Tester 30.8. Also those oils with which a theoretical increase in weight was not reached on account of the decomposition of the oxidation products, were found to be more dangerous when tested in the Mackey Tester; and this, coupled with the fact that moist air was shown to aid in the decomposition of the oxidised oils, and particularly of the fatty acids, probably helped to explain why moist air should aid in the firing of the oils when on the fibre. That the nature of the fibre is of some importance from a firing standpoint was shown from the treatment of "Black Oil Cake," obtained in the Heavy Woollen District. Cake containing cotton fibre could not be stored without risk of firing, whereas cake free from cotton fibre might be stored for a considerable period.

Communications.

A SIMPLE INSTRUMENT FOR THE DETERMINATION OF VISCOSITY.

BY ALAN SPEEDY.

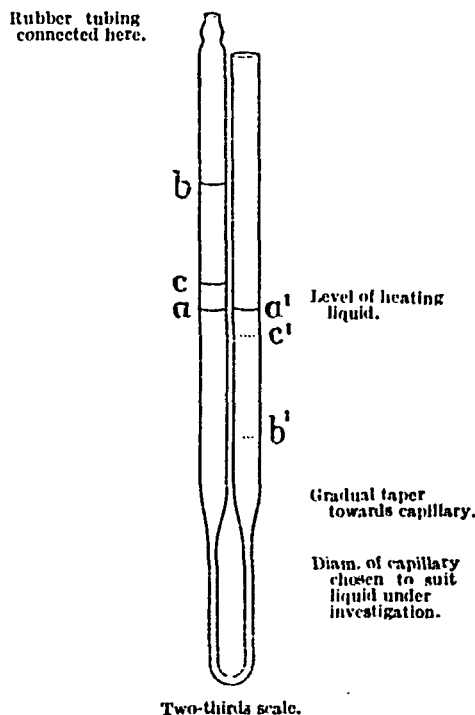
In the determination of viscosity by the aid of viscometers of the Ostwald type, it is customary to immerse the whole apparatus in a medium of high boiling point. The use of a fairly large quantity of some oil or wax transparent at the temperature of observation is thereby necessitated.

In the simple instrument described below, all difficulty in reading the marks is avoided by placing them above the surface of the liquid, which, therefore, need not be transparent and of which only a moderate quantity is required.

The instrument consists of a piece of glass

tubing drawn out to form a capillary and bent into U shape, as shown in the figure.

The liquid of which the viscosity is to be determined is filtered into the viscometer, which is clamped vertically in the bath so that the level



marks, aa' , are just above the surface of the heating liquid. The bath is now heated to the required temperature and after a few minutes the levels, aa' , are carefully adjusted. By means of a piece of rubber tubing the liquid is then slowly sucked up the left limb of the tube until it passes the level, b . It is then allowed to descend. The time taken to fall from b to c is recorded on a stop watch, and the experiment repeated as a check.

Part of the liquid under observation is above the surface of the heating liquid and is, therefore, at a slightly lower temperature, but as the level falls, this part of the liquid regains its former temperature. The error due to unequal viscosity in different regions arising in this way is negligible. It is only the viscosity of the liquid in the capillary tube that counts. The thinness of the wall of the capillary tube ensures that the liquid passing through the tube is at the temperature of the bath. It should be observed that the column of liquid, bc , never reaches the capillary. The level, b' , is well above the point where the constriction in the right limb of the tube begins. The time of flow is taken from b to c only, because on approaching a the motion becomes slow and uncertain.

The constant of the instrument can be obtained by calibrating it with pure phenol (see A. E. Dunstan, this J., 1912, 31, 1003) or sulphuric acid (see Proc. Chem. Soc., 1914, Vol. 80).

The instrument may conveniently be strapped to a thermometer and suspended in the heating liquid, which is contained in a boiling tube. The cheapness of the apparatus renders it possible to choose from a range of tubes one with a capillary of diameter best suited to the viscosity of the liquid which is to be investigated. The best results are obtained if the time of flow is about 1–2 mins. at the temperature of observation.