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XXXVIII. *Some Remarks on the Substances discovered by Mr. Stenhouse in the Roccella tinctoria and Evernia Prunastri.*
By EDWARD SCHUNCK*.

IN a paper read some months ago before the Royal Society, Mr. Stenhouse has communicated the results of an elaborate investigation of the proximate principles of some of the lichens, especially the *Roccella tinctoria* and the *Evernia Prunastri*. The multitude of new observations recorded by Mr. Stenhouse in his valuable paper, and the accuracy with which he has examined the composition of the various substances obtained by him, would seem at length to confer on this part of organic chemistry the degree of completeness required in the present state of the science. Nevertheless, on comparing his results with those of his predecessors on this field of inquiry, it may be asked how it is possible for so many persons to examine the same subject and arrive at such widely different results; and some doubt may arise in the mind either as to the skill of some of the investigators, or as to the accuracy of the methods at present employed in organic chemistry. The *Roccella tinctoria* has now been examined four times, and the discrepancies between the several investigations are very striking. Heeren discovered in it a substance which he called *erythrine*. Kane obtained from it a substance differing in its properties from Heeren's erythrine, and which he named *erythryline*. In my examination of the plant I found a body corresponding to Heeren's erythrine and Kane's erythryline, but differing in properties from both, and in composition from the latter. To this substance I gave the name of *erythric acid*. Lastly, Mr. Stenhouse has obtained from different varieties of the *Roccella tinctoria* no less than three different substances, similar to, but not identical with, those discovered by Heeren, Kane and myself. If, therefore, we are to believe all the

* Communicated by the Author.

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statements of those who have examined the subject, the same plant, according to its varieties and the places of its growth, produces sometimes one, sometimes another, of six different bodies, each of which may entirely supply the place of any one of the others. This circumstance is contrary to analogy; since it is more common to find plants differing totally from one another produce the same substance, than to find the same plant in different circumstances secrete different substances. From the *Evernia Prunastri*, again, Messrs. Rochleder and Heldt obtained lecanoric acid, while to Mr. Stenhouse the same plant afforded evernic acid. There can of course be no doubt that the *Roccella tinctoria* does in reality produce substances very different from one another according to the place in which it grows. I shall, however, endeavour to show in the following pages that it is possible, by comparing these substances, to find a link by which to bind them together and bring them into harmony with one another.

Now on comparing together the various colour-giving substances found at different times in the *Roccella tinctoria*, we shall find that all or several of them have certain properties in common. They all give red colouring matters when dissolved in ammonia and exposed to the air. In the next place, erythrine, erythryline and erythric acid, all produce, under certain circumstances, a bitter substance; but these circumstances are not the same with all three, and the bitter substance itself is also different in each case. Erythric acid and the two orsellic acids of Mr. Stenhouse are decomposed by alkalies into carbonic acid and orcine, accompanied in the case of erythric acid, according to Mr. Stenhouse, by another body, viz. pseudo-orcine. Lastly, all these substances agree with one another and with lecanoric acid, in giving, when treated with boiling alcohol, crystallized bodies soluble in boiling water, which have been proved to be æthers.

It is to the latter circumstance that I wish in the first place to draw attention. Lecanoric acid, erythrine, erythryline, erythric acid, alpha-orsellic and beta-orsellic acid, all give, when treated with boiling alcohol, solid crystallizable æthers. The æther produced in this way from erythrine was called by Heeren, who was ignorant of its true nature, *pseudo-erythrine*. Let us now compare together the composition of these various æthers, as determined by Kane, Rochleder and Heldt, Stenhouse and myself.

The æther from erythrine consists, according to Kane, of—

	I.	II.
Carbon . .	60·33	60·43
Hydrogen . .	6·20	6·31
Oxygen . .	33·47	33·26

Lecanoric æther :—

	From <i>Lecanora Parella</i> .			
	S.			
	I.	II.	III.	From <i>Evernia Prunastri</i> . Rochleder and Heldt.
Carbon . .	60·74	60·73	60·57	61·14
Hydrogen .	6·25	6·13	6·39	6·38
Oxygen . .	33·01	33·14	33·04	32·48

Æther from erythric acid :—

	S.			Stenhouse.	
	I.	II.	III.	I.	II.
Carbon . .	60·65	60·72	60·57	60·65	60·74
Hydrogen .	6·13	6·14	5·97	6·33	6·31
Oxygen . .	33·22	33·14	33·46	33·02	32·95

Æther from alpha-orsellic acid (orsellesic æther of Stenhouse):—

	I.	II.
Carbon . .	61·24	61·13
Hydrogen .	6·26	6·15
Oxygen . .	32·50	32·72

Æther from beta-orsellic acid (Stenhouse):—

	I.	II.	III.
Carbon . .	60·82	60·75	60·83
Hydrogen .	6·27	6·15	6·27
Oxygen . .	32·91	33·10	33·00

On comparing the preceding analyses with one another, any one conversant with organic chemistry will immediately perceive that the differences are not greater than those usually found in analysing the same substance from different sources. The properties of these æthers are also identical as far as they are known. I found lecanoric æther to have exactly the same properties as those ascribed to pseudo-erythrine by Heeren and Kane. I was also unable to discover any characteristic difference between lecanoric æther and the æther from erythric acid. Mr. Stenhouse says of orsellesic æther, "This æther cannot be distinguished in its external properties from the lecanoric and erythric æthers;" and the æther from beta-orsellic acid, according to him, "cannot be distinguished in appearance from the orsellesic, lecanoric or erythric æthers, with which bodies in its properties and reactions it very closely corresponds." I therefore maintain that all these æthers are nothing more nor less than lecanoric æther. Now lecanoric æther consists of $C_{18}H_8O_8 + C_4H_5O = C_{22}H_{13}O_9$, and its calculated composition is as follows :—

22 eqs. Carbon	. .	1650	60·83
13 ... Hydrogen	. .	162·2	5·98
9 ... Oxygen	. .	900	33·19
		<hr/> 2712·2	<hr/> 100·00

It will be seen that the numbers of almost all of the above analyses closely correspond with those of the calculated composition of lecanoric æther. There is therefore at present nothing to oppose the hypothesis that pseudo-erythrine, erythric æther, and the orsellic æthers, are all identical with lecanoric æther*.

If this conclusion be accepted, it follows necessarily that erythrine, erythryline, erythric acid, and the two orsellic acids, must contain lecanoric acid; and not only the elements of that acid, but the acid as such. For if by acting on a certain substance with boiling alcohol we obtain the æther of a certain acid, it follows that this acid must have been contained in the original substance as such; since it would be contrary to all analogy to suppose that boiling alcohol is capable of exerting such a powerful influence on any substance as to make the elements of the latter arrange themselves in such a way as to form an acid, with which the basis of the alcohol might combine to produce an æther, the affinity of oxide of ethyle for organic acids being in general so weak as to render the intervention of a strong acid necessary to cause the decomposition of the alcohol before the combination can take place.

Having now obtained a basis for comparing the various colour-giving substances of the *Roccella tinctoria*, I shall in the first place proceed to the consideration of erythric acid.

* I have supposed that the formula given above for lecanoric acid, viz. $C_{18}H_9O_8$, is firmly established, and I am not aware that any experiments have been made tending to establish a better. Mr. Stenhouse, however, in a recent paper on Alpha-orcine and Beta-orcine (Phil. Mag., vol. xxxiii. p. 1), has given a new formula for orcine, called by him alpha-orcine, viz. $C_{21}H_{15}O_9$. Dry orcine, according to him, is $C_{21}H_{12}O_6$. This change he has made apparently in order to obtain a formula corresponding with the analyses of dry orcine; since the composition of crystallized orcine, as determined by him, agrees much better with the old formula $C_{16}H_{11}O_7$ than with the new one. I have myself never been able to obtain dry orcine of uniform composition; and even if obtained of uniform composition, as stated by Mr. Stenhouse, it may be questioned whether it is not a mixture of various hydrates in some proportion determined by the temperature and the length of time occupied in drying. At all events, if we change the formula for orcine, the formula for lecanoric acid must also necessarily be changed, since lecanoric acid minus carbonic acid plus water is orcine. It will, however, be found impossible to find a formula which will express the composition of lecanoric acid, and will at the same time be in accordance with Mr. Stenhouse's new formula for orcine. I therefore prefer retaining the old formulæ for orcine and lecanoric acid, the more so as these also harmonise with those of lecanoric æther and orceine.

The first point to be determined is, whether the substance to which I gave the name of erythric acid is the same as the erythric acid of Mr. Stenhouse. Both give when treated with boiling water picro-erythrine. Mr. Stenhouse, however, states that picro-erythrine, when decomposed with alkalis, gives carbonic acid, and a new substance called by him *pseudo-orcine*, while I was of opinion that it is decomposed into carbonic acid and orcine. Being still in possession of a sufficient quantity of picro-erythrine, I treated some of it with boiling caustic baryta, and after filtering, precipitating the excess of baryta by a stream of carbonic acid gas and evaporating, I obtained a mass of crystals, which, after being treated with æther and crystallized over again, possessed the properties and composition ascribed by Mr. Stenhouse to pseudo-orcine. The æther on evaporation gave a quantity of orcine. This property of picro-erythrine, the discovery of which is due to Mr. Stenhouse, is so characteristic as to prove at once that the erythric acid examined by him is identical with that described by me. As Mr. Stenhouse seems to have obtained the acid in a state of much greater purity than I did, I shall lay no stress on the differences found by us in its composition, but shall at once accept the numbers given by him as expressing the true composition.

Mr. Stenhouse found erythric acid to consist in 100 parts of—

	I.	II.	III.
Carbon . .	56·85	56·94	57·14
Hydrogen . .	5·56	5·33	5·63
Oxygen . .	37·59	37·73	37·23

The formula given by him is $C_{20}H_{11}O_{10}$.

Now I propose to change this formula into $C_{42}H_{23}O_{21}$. The calculated composition will then be as follows:—

42 eqs. Carbon . .	3150	56·89
23 ... Hydrogen . .	287	5·18
21 ... Oxygen . .	2100	37·93
	<hr/> 5537	<hr/> 100·00

It will be seen that Mr. Stenhouse's numbers agree sufficiently well with this formula; and I shall now show how, by means of it, we may explain the various changes which the acid undergoes.

On calculating the formula $C_{24}H_{16}O_{14}$ for 100 parts, the following results are obtained:—

24 eqs. Carbon . .	1800	52·94
16 ... Hydrogen . .	199·6	5·87
14 ... Oxygen . .	1400	41·19
	<u>3399·6</u>	<u>100·00</u>

Picro-erythrine contains in 100 parts—

	Stenhouse.		
	I.	II.	S.
Carbon . .	53·07	53·23	52·86
Hydrogen . .	6·08	5·95	6·22
Oxygen . .	40·85	40·82	40·92

The formula $C_{24}H_{16}O_{14}$ therefore expresses the composition of picro-erythrine. The formation of pseudo-orcine still remains to be explained in harmony with the preceding formulæ.

If from 1 eq. picro-erythrine = $C_{24}H_{16}O_{14}$
 we subtract 2 eqs. carbonic acid = C_2O_4

and add 12 eqs. water = $H_{12}O_{12}$

we obtain = $C_{22}H_{28}O_{22}$

The formula $C_{22}H_{28}O_{22}$, calculated for 100 parts, gives—

22 eqs. Carbon . .	1650	39·29
28 ... Hydrogen . .	349·4	8·32
22 ... Oxygen . .	2200	52·39
	<u>4199·4</u>	<u>100·00</u>

On subjecting pseudo-orcine, prepared according to Mr. Stenhouse's method, to analysis, I obtained the following results:—

I. 0·5695 grm. substance gave 0·8270 carbonic acid and 0·4355 water.

II. 0·4130 grm. gave 0·6020 carbonic acid and 0·3240 water.

It therefore consists in 100 parts of—

	Stenhouse.				
	I.	II.	I.	II.	III.
Carbon . .	39·60	39·75	39·46	39·42	39·36
Hydrogen . .	8·49	8·71	8·55	8·30	8·60
Oxygen . .	51·91	51·54	51·99	52·28	52·04

It will be seen that the formulæ here adopted for erythric acid, picro-erythrine and pseudo-orcine, agree very well with

the composition of these substances as determined by Mr. Stenhouse; while the formulæ given by that gentleman for picro-erythrine, $C_{34}H_{23}O_{20}$, and pseudo-orcine, $C_{10}H_{13}O_{10}$, are not reconcilable with one another, nor with that given by him for erythric acid, viz. $C_{20}H_{11}O_{10}$. By adopting the above formulæ, the changes which erythric acid undergoes admit of an easy explanation. According to my view, erythric acid may be considered as a compound of lecanoric acid and picro-erythrine. It is a coupled acid, in which the saturating power of the simple acid is not destroyed. When erythric acid is treated with boiling water, the lecanoric acid is decomposed into orcine and carbonic acid, so that on evaporating the solution, a mixture of picro-erythrine and orcine is obtained. When erythric acid is treated with boiling alcohol, the lecanoric acid contained in it is changed into lecanoric æther*, and the liquid contains picro-erythrine. When picro-erythrine is treated with alkalis, it loses carbonic acid, and taking up several equivalents of water, is changed into pseudo-orcine†. When, however, erythric acid is acted on by alkalis, the lecanoric acid contained in it is changed into orcine and carbonic acid, and the picro-erythrine is changed into pseudo-orcine and carbonic acid, so that a mixture of orcine and pseudo-orcine is obtained.

As the names picro-erythrine and pseudo-orcine have a barbarous sound, and the latter is also inappropriate, I propose to change the former into *Erypicrine* and the latter into *Eryglucine*. Erythric acid might therefore be called erypicrine-lecanoric acid.

Mr. Stenhouse has discovered in a South American variety of the *Roccella tinctoria* an acid, which he calls *alpha-orsellic acid*; and in a Cape of Good Hope variety of the same plant, a very similar acid, called by him *beta-orsellic acid*. He has

* It follows that Mr. Stenhouse's erythric-methylic æther is, in fact, lecanoric-methylic æther. Its formula must therefore be $C_{18}H_8O_8 + C_2H_5O = C_{20}H_{11}O_9$. Its composition would then be as follows:—

				Stenhouse.	
				I.	II.
20 eqs. Carbon	1500	59.12	59.30	59.36	
11 ... Hydrogen	137.2	5.40	5.52	5.69	
9 ... Oxygen	900	35.48	35.18	34.95	
		<hr/>	<hr/>	<hr/>	<hr/>
		2537.2	100.00	100.00	100.00

† I am inclined to think that the orcine, which is found in small quantity accompanying the pseudo-orcine derived from the decomposition of picro-erythrine, was produced from erythric acid left undecomposed among the picro-erythrine.

given for the former the formula $C_{32}H_{16}O_{14}$, and for the latter $C_{34}H_{18}O_{15}$.

They consist in 100 parts of—

	Alpha-orsellic acid.			Beta-orsellic acid.	
	I.	II.	III.	IV.	V.
Carbon . .	60·00	60·98	60·78	60·07	60·20
Hydrogen .	5·03	5·00	4·98	5·06	5·26
Oxygen . .	34·97	34·02	34·24	34·87	34·54

Now if these two acids are distinct, they are certainly isomeric, since the differences in the preceding analyses are not sufficiently great to justify the establishment of distinct formulæ. I propose for these acids, therefore, the formula $C_{34}H_{18}O_{14}$. The calculated composition will then be as follows:—

34 eqs. Carbon . .	2550	61·08
18 ... Hydrogen . .	224·6	5·38
14 ... Oxygen . .	1400	33·54
	<hr/> 4174·6	<hr/> 100·00

If this be the true composition of orsellic acid, orsellate of baryta must be $C_{34}H_{18}O_{14} + BaO$, and must have the following composition:—

		Alpha-orsellate. Stenhouse.		Beta-orsellate.
		I.	II.	
34 eqs. Carbon .	2550	49·69	49·36	49·46
18 ... Hydrogen	224·6	4·37	3·83	3·79
14 ... Oxygen .	1400	27·30	27·32	27·54
1 ... Baryta .	956·8	18·64	19·49	18·52
	<hr/> 5131·4	<hr/> 100·00	<hr/> 100·00	<hr/> 100·00

Assuming, then, that the above formula is the correct one, it follows that—

$$\begin{array}{rcl}
 \text{if from 1 eq. orsellic acid} & . & . = C_{34}H_{18}O_{14} \\
 \text{we subtract 1 eq. lecanoric acid} & & = C_{18}H_8O_8 \\
 & & \hline
 \text{and add 1 eq. water} & . & . = C_{16}H_{10}O_6 \\
 & & \hline
 \text{we obtain 1 eq. crystallized orcine} & = & C_{16}H_{11}O_7
 \end{array}$$

According to this view, then, orsellic acid is a coupled acid, consisting of orcine and lecanoric acid; or it is orcine-lecanoric acid, just as erythric acid is erypicrine-lecanoric acid. It is therefore obvious how the formation of lecanoric æther

by means of boiling alcohol, and of orcine by means of alkalis, takes place.

The formation of erythrelesic and orsellesic acids still remains to be explained. If the view here taken be the correct one, it follows that these two acids must be identical with lecanoric acid combined with one equivalent of water, *i. e.* $C_{18}H_8O_8 + HO = C_{18}H_9O_9$. Its composition would then be as follows:—

			Orsellesic acid.	
			I.	II.
18 eqs. Carbon	. 1350	57·14	57·99	57·90
9 ... Hydrogen	112·3	4·75	5·25	5·08
9 ... Oxygen	900	38·11	36·76	37·02
	<hr/>	<hr/>	<hr/>	<hr/>
	2362·3	100·00	100·00	100·00

The composition of erythrelesic acid not having been examined, it is impossible to arrive at any conclusion in regard to it.

I may here mention, that I some time ago discovered that if lecanoric acid be dissolved in caustic baryta and again precipitated, it is found to have taken up one equivalent of water, and been changed into $C_{18}H_9O_9$, and this water it does not again lose. This equivalent of water is replaced in the æther compound by C_4H_5O ; so that it appears that this æther forms no exception to the general rule, according to which the oxide of ethyle in the æthers always replaces the water of the hydrated acid. The body $C_{18}H_8O_8$ might still retain the old name of lecanorine.

Mr. Stenhouse's evernic acid may also be shown to belong to the same class of bodies as the preceding. Mr. Stenhouse gives for evernic acid the formula $C_{34}H_{16}O_{14}$. I propose to change this to $C_{36}H_{17}O_{15}$. It would then be composed as follows:—

			Stenhouse.	
			I.	II.
36 eqs. Carbon	. 2700	61·19	61·63	61·61
17 ... Hydrogen	212·1	4·78	5·00	5·16
15 ... Oxygen	1500	34·03	33·37	33·23
	<hr/>	<hr/>	<hr/>	<hr/>
	4412·1	100·00	100·00	100·00

The potash and baryta salts, when calculated according to this new formula, also give numbers which agree sufficiently well with those found by Mr. Stenhouse.

Evernate of potash:—

				Stenhouse.	
				I.	II.
36 eqs. Carbon	. 2700	55·22		55·82	55·28
16 ... Hydrogen	199·6	4·08		4·39	4·30
14 ... Oxygen	1400	28·64		27·49	28·12
1 ... Potash	. 589·9	12·06		12·30	12·30
				4889·5	100·00
				100·00	100·00

Evernate of baryta:—

				Stenhouse.	
				I.	II.
36 eqs. Carbon	. 2700	51·36		50·30	50·31
16 ... Hydrogen	199·6	3·79		4·10	3·96
14 ... Oxygen	1400	26·65		27·08	27·38
1 ... Baryta	. 956·8	18·20		18·52	18·35
				5256·4	100·00
				100·00	100·00

If from 1 eq. evernic acid . . . = $C_{36}H_{17}O_{15}$ we subtract 1 eq. lecanoric acid . = $C_{18}H_8O_8$ and add 1 eq. water = $C_{18}H_9O_7$ we obtain 1 eq. evernesic acid . = $C_{18}H_{10}O_8$

Evernic acid may therefore be considered as a coupled acid, consisting of lecanoric and evernesic acids. It consequently appears probable that the *Evernia Prunastri* may sometimes contain lecanoric acid only, as found by Rochleder and Heldt, and sometimes lecanoric and evernesic acids combined to evernic acid, as found by Mr. Stenhouse. The orcine which is produced on treating evernic acid with alkalis, must be derived from the lecanoric acid. Evernesic acid being a more stable body than lecanoric, resists the action of alkalis; and on supersaturating with a mineral acid, it is precipitated. It seems probable that if evernic acid were dissolved in caustic alkali without adding an excess of the latter, and the solution just heated to the boiling-point, as in the case of orsellic acid, then, on adding a strong acid, a mixture of lecanoric and evernesic acids would be precipitated. But as Mr. Stenhouse treated his evernic acid with an excess of caustic potash or baryta, and boiled for some time, the lecanoric acid would of course be decomposed. On treating evernic acid with boiling alcohol also, I should suppose that lecanoric æther would be generated, as well as evernesic æther.

Mr. Stenhouse, however, added caustic potash to the alcohol, so that any lecanoric acid or lecanoric æther present must necessarily have been decomposed.

I have still a few words to say in regard to Kane's erythryline. Kane has given this name to the colour-producing substance found by him in the *Roccella tinctoria*. It is analogous to erythric acid; but in composition it differs so widely from the latter, as to preclude the supposition of their being identical. Since erythryline gives among the products of its decomposition a body of the same composition as lecanoric æther, I infer that it contains lecanoric acid in a similar state of combination as in erythric, orsellic and evernic acids. Kane gives as the formula of erythryline, $C_{22}H_{16}O_6$. I propose to change this into $C_{42}H_{29}O_{12}$. The composition would then be as follows:—

					Kane.	
					I.	II.
42 eqs. Carbon	.	3150	66·85		66·88	65·53
29 ... Hydrogen		361·9	7·68		8·13	8·38
12 ... Oxygen	.	1200	25·47		24·99	26·09
					<hr/>	<hr/>
					4711·9	100·00
					100·00	100·00

If this formula be adopted, it follows that —

$$\begin{array}{lcl} \text{if from 1 eq. erythryline} & . & . & . & = C_{42}H_{29}O_{12} \\ \text{we subtract 1 eq. lecanoric acid} & & & & = C_{18}H_8O_8 \end{array}$$

$$\begin{array}{lcl} & & & & C_{24}H_{21}O_4 \\ & & & & H_2O_2 \\ \text{and add 2 eqs. water} & . & . & . & = \hline \end{array}$$

$$\begin{array}{lcl} \text{the resulting formula is} & . & . & . & C_{24}H_{23}O_6 \end{array}$$

Now $C_{24}H_{23}O_6$ is the formula which I have given in my paper on the *Roccella tinctoria* for roccellic acid. It would appear, therefore, that erythryline is equal to lecanoric acid plus roccellic acid minus two equivalents of water. As Kane has mentioned no experiments on its products of decomposition, no further reasons can be given for or against this view of its composition.

In my opinion, therefore, erythryline, erythric acid, orsellic acid and evernic acid, are coupled acids, in which lecanoric acid forms the acid ingredient, and they might be called respectively roccell-lecanoric, erypicrine-lecanoric, orcin-lecanoric and evernesine-lecanoric acids. They resemble those coupled acids, which consist of simple acids united with neutral bodies, and which saturate the same quantity of any base as the simple acids contained in them. They are similar to hippuric acid, which may be considered as a compound of

benzoic acid and glycoll minus two equivalents of water. Before this view, however, can be considered as established, it will be necessary to examine carefully the æthers derived from lecanoric, erythric and orsellic acids, in regard to their crystalline form, specific gravity, action on light, &c., and also to compare accurately together orsellesic, erythrelesic and lecanoric acids. If the æthers derived from various sources should possess the same physical properties, and if orsellesic and erythrelesic acids should prove to be identical in properties and composition with lecanoric acid which has been dissolved in alkali and reprecipitated, then I contend that my view of the composition of these bodies will best explain the manifold changes which they undergo.

Rochdale, August 26, 1848.

XXXIX. *An Account of some Experiments on Volta-Electric Induction.* By REUBEN PHILLIPS, Esq.*

THE apparatus I employed consisted of three similar coils of covered copper wire, number 16, each coil being about 3·5 inches diameter, and containing eleven yards of wire; the ends of the wire were left exposed, so that by binding-screws the coils could be united in any order. I call these coils respectively A, B and C. To ascertain the force and direction of the induced current, I generally used an indicating helix containing a needle; this helix was made by winding covered copper wire, No. 24, on a piece of glass tube about $\frac{1}{15}$ th of an inch in diameter; the wire was wound on the glass until it had acquired the depth of nine layers. This helix, which I call the *indicator*, was maintained in the same relative position with regard to an induced current, and the needles were always inserted with their points in the same relative direction; consequently the direction of the magnetism imparted by a current traversing the indicator was always the same for currents in that direction. I call a needle after it has been placed in the indicator, the *indicating needle*; the needles employed were of one size, and by the same maker. The magnetism imparted to them by the indicator was discovered by presenting them to one of two sewing-needles, which had been mag-

* When I had completed this paper, which I thought was altogether new, I acquainted Dr. Faraday with it, who informed me Dr. Henry had previously given the same results in a paper entitled "Contributions to Electricity and Magnetism" (Transactions of the American Philosophical Society, vol. vi.); however, Dr. Faraday thought very well of my paper and advised its publication. It is proper to remark, the paper has been a little altered since Dr. Faraday expressed this good opinion of it.