

loudness, but differing markedly in what is called quality or *timbre*, were alternately sounded, two perfectly distinct figures were obtained, each presenting itself again and again for many alternations the instant its own note was sounded, and remaining constant until that note ceased. By this apparatus, therefore, permanent pictures of the relative quality of musical sounds may be secured.

I content myself here with a description of the phenomena I have observed, and make no attempt at determining the mechanical conditions under which they occur. It may, however, be worth while to remark that the most striking feature of the figures above described, the vortices, can be exactly reproduced with the caoutchouc tube apparatus by gently sucking a little air through it, taking care that the whole opening of the tube is not in simultaneous contact with the lips, and that its other end is not completely closed by the disc and film.

Before concluding I wish to draw attention to some allied phenomena described by Mr. E. B. Tylor in "Nature," for May, 1877, p. 12. Distinct patterns were obtained by him, but it would appear from the directions he gives for producing "a film more free from interference-colours, so as to display the vibration-figures on an almost clear ground" that no permanent colour-patterns are in question in his letter. He speaks indeed of "the gorgeous scenic effect of the masses of prismatic colour whirled hither and thither by the musical vibrations," but of nothing more fixed and regular. The mode of experimenting adopted by him on that occasion suggested the third form of apparatus described in the present paper.

February 7, 1878.

Sir JOSEPH HOOKER, K.C.S.I., President, in the Chair.

The Presents received were laid on the table and thanks ordered for them.

The following Papers were read:—

- I. "On the Comparison of the Standard Barometers of the Royal Observatory, Greenwich, and the Kew Observatory." By G. M. WHIPPLE, B.Sc., Superintendent of the Kew Observatory. Communicated by order of the Kew Committee, WARREN DE LA RUE, F.R.S., Vice-Chairman. Received November 26, 1877.

The Standard Barometers of these two important establishments, up to within a recent date, had never been compared directly, although

Fig. 1.

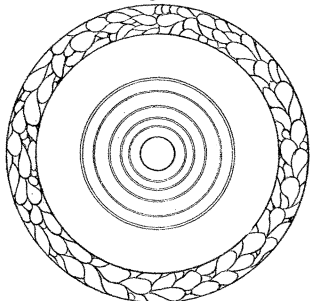


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.

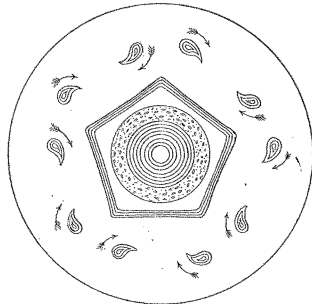


Fig. 6.

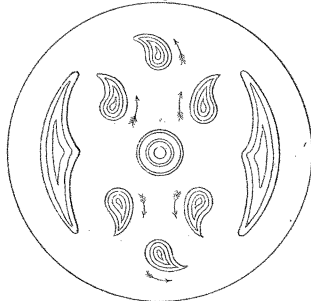


Fig. 7.



Fig. 8.

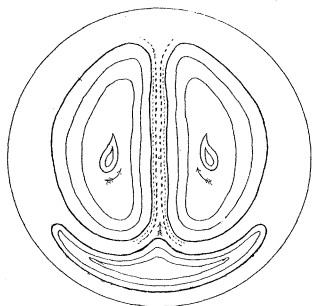


Fig. 9.

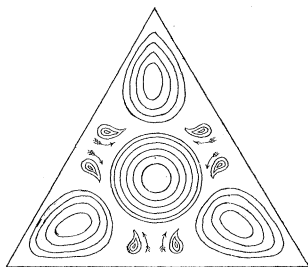


Fig. 10.

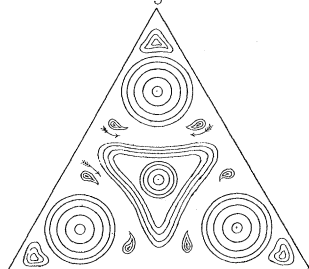


Fig. 11.

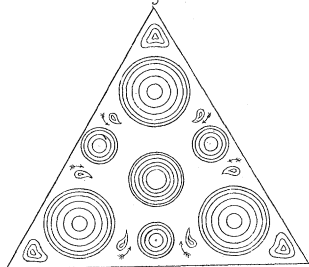


Fig. 12.

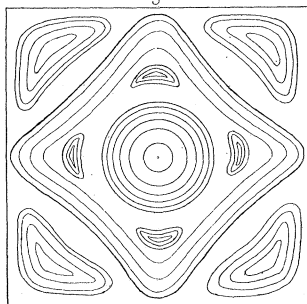


Fig. 13.

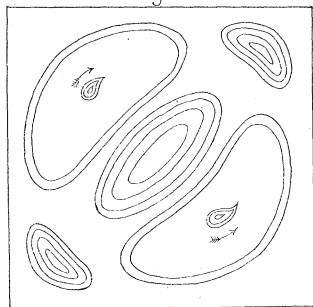
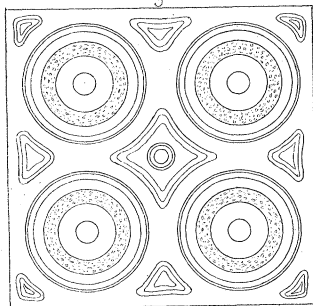


Fig. 14.



from time to time indirect comparisons have been made by persons not connected officially with either.

Attention has recently been drawn to the subject by the publication of a memoir by Dr. H. Wild, Director of the Central Physical Observatory, St. Petersburg, entitled "Ueber normal-Barometer und ihrer Vergleichung," in which the author states (p. 100) that the standard barometer of the Royal Observatory reads 0·465 m.m., or 0·018 inch lower than that of the Kew Observatory, arriving at that conclusion by means of somewhat circuitous comparisons. Professor Mohn, of Christiania, in 1876, writes also that he finds the difference Kew — Greenwich to be + 0·49 m.m., or + 0·019 inch.

In 1869 the late Colonel Strange made a comparison between the two standards by means of a barometer which he had conveyed from the one observatory to the other, the results of which are stated by him to be as follows:—

By comparison No. 1	Greenwich lower than Kew	0·009 inch.
"	" 2	" 0·006 "
"	" 3	" 0·004 "

In consequence of these statements the Kew Committee made application to the Astronomer Royal for permission to make a direct comparison between the two instruments, and received from him a courteous consent to their proposition.

Accordingly, having selected four barometers—Adie 655, Adie 657, Negretti and Zambra $\frac{C}{429}$, and Negretti and Zambra $\frac{C}{431}$, all standards on the Fortin principle—as suitable instruments for the purpose, I made arrangements to convey them to Greenwich and back safely in a carriage.

On April 23rd, 1877, Mr. Baker and I made a set of observations of the two large Kew standards, constructed by the late Mr. Welsh; Newman 34 [the working standard of the Observatory], Adie 655 and Adie 657, and subsequently of Newman 34, and the two Negretti and Zambra standards.

The latter we also compared again on the morning of the 24th, before starting for Greenwich.

Having carefully packed the instruments, accompanied by an assistant, I went to the Royal Observatory, and there suspended the barometers in the large room of the Magnetic Observatory, facing and about eight feet distant from the standard barometer (Newman 64).

After leaving the instruments about an hour, in order that they might assume the correct temperature of the room, which did not differ greatly from that of the external air at the time, we made a set of twelve readings of all the four instruments and of the Greenwich standard, myself and the assistant reading them alternately, the tem-

perature of each barometer being also noted by the observer at the time of observation.

On the 25th and 26th of April Messrs. Ellis, Nash, and other Greenwich observers made a set of nine comparisons, and on the latter day Messrs. Baker and Foster, two Kew observers, went to Greenwich and made twelve comparisons of the five instruments, and then dismounted, packed, and brought them back to the Kew Observatory, again suspending them in their places.

On April 27th the four hack barometers (to use a term happily suggested by Mr. Galton) were again read twelve times with the Kew standard of reference barometer, Newman 34, by the same three Kew observers. The result of this set of comparisons shows the mean difference between Kew and Greenwich to have been (Greenwich—Kew)=+·0016 inch.

2nd Comparison.

The four hack barometers were again on the 1st of May compared at Kew with Newman 34, and then conveyed to Greenwich, where they were put up in the same place as before, and read again in a similar manner to that employed on the occasion of the previous visit.

On the 1st the Kew assistants made twelve sets of readings; on the 2nd and 3rd the Greenwich observers made twelve sets of comparisons. On the 4th we made a like number of sets, returning the instruments subsequently to Kew, where they were read on the 5th with the Kew standard of reference.

The result of the second series of comparisons gives a mean difference (Greenwich—Kew)+0·0007 inch.

3rd Comparison.

Before making this comparison the tube of Adie 655 was accidentally broken, and having been repaired and refilled, its index error was somewhat changed; also barometers Negretti and Zambra $\frac{C}{429}$ and $\frac{C}{431}$ having been removed from the Observatory by the makers, two other instruments, also by Negretti and Zambra, Nos. † 903 and † 1105, were selected with which to make the comparisons.

On the 14th May these four barometers were all compared ten times with the Kew barometer (Newman 34), the observers being the same as before.

The next day they were taken to Greenwich, and hung up in the usual place. Due time having been allowed for them to become settled, and the temperature equalised, ten sets of readings were made precisely in a similar manner to the previous ones.

On the 16th the Greenwich observers made eight sets of readings, on the 17th seven sets, and on the morning of the 18th two sets.

Later on the same day Messrs. Baker and Foster made twelve sets, carrying the barometers again back to Kew, where, on the 19th, twelve sets of observations were finally taken.

On the 23rd the Kew barometer (Newman 34) was again compared with the two Normal barometers of the Observatory, and its correction found to be -0.007 inch, the same as determined on April 23rd.

The readings at Greenwich on the 17th May were taken at a time when the pressure was rapidly falling, and a storm passing over the Observatory; and on the 18th its effect had not completely passed off, the wind being high and the temperature changing somewhat quickly.

The observations made on these two days were discordant from these causes, and have therefore been left out of the comparison, and the result of the third series of observations gives the difference (Greenwich — Kew) $+0.0014$ inch.

We then have the following determinations :—

Mean difference from 1st series of 128 comparisons $+0.0016$ inch.					
„	„	„	2nd	„	144
„	„	„	3rd	„	72
				Final mean of	344
				„	$+0.0012$

This value is unchanged if we weight the determinations proportionally.

A correction of -0.006 inch has been applied throughout to the readings of the Greenwich standard; this correction having been made by the Astronomer Royal to all the readings of that instrument since August 30th, 1866 (when the long sliding rod, after removal, was replaced), to make them accord with the old Royal Society standard's indications.

Throughout the observations the temperatures of all the portable barometers were observed by means of thermometers fixed to the middle of their brass tubes, having the bulbs in immediate contact with the mercurial column.

The errors of these thermometers were all carefully determined at Kew, and every reading has been corrected to the Kew standard.

The Greenwich standard barometer is provided with two thermometers—a large one with a bulb approximately of the same diameter as the barometrical column, and placed about half way up, but at a distance of 1.25 inches in front of it—and a small thermometer not divided on its stem, whose bulb is immersed in the cistern of the barometer itself.

The readings of the latter instrument do not admit of great exacti-

tude, and therefore have not been considered in the discussion, although they were made.

As the position of the Greenwich standard barometer precludes its being read by daylight, two gas burners are used to illuminate it at the time of observation, one being fixed at the level of the pointer in the cistern, the other at the barometric height. The flame of these burners is raised only at the instant of observation.

The gas lights being immediately behind the barometer, and distant about six inches, somewhat heat it, and it was thought that probably the thermometer in front of the instrument might not, perhaps, indicate the true temperature of the mercurial column and scale.

With a view to determine the amount of this heating effect, on October 8th I took six standard thermometers to Greenwich, and, attaching them to the barometer in close contact with the tube and scale, three in front and three behind, made a series of observations in order to investigate approximately the distribution of temperature throughout the instrument.

This was found to be as follows when the gas burners were turned low, as in their ordinary condition.

Mean of Lower thermometers. . . . .	..	..	..	..	= 59°·70
„ Middle „ . . . . .	..	..	..	..	= 61°·07
„ Upper „ . . . . .	..	..	..	..	= 62°·46
<hr/>					
„ Whole „ . . . . .	..	..	..	..	= 61°·06
„ Greenwich attached thermometer	61°·42				
Correction for Index error			— 0°·90	..	= 60°·52
<hr/>					
Difference . . . . .	..	..	..	..	= 0°·54
<hr/>					
Mean of Greenwich cistern thermometer	..	..			= 58°·26
<hr/>					

When, however, the gas burners were turned on full, the temperature of the upper part of the barometer became much increased, a rise of 7·1° taking place in five minutes, whilst the thermometer attached to the barometer was only affected to the extent of 0°·8.

Great care was exercised in turning down the lights immediately after reading during the periods of comparison, so that it is assumed that no instance of such a great irregularity in the distribution of temperature ever occurred.

As from the table it appears that the temperature indicated by the barometer's attached thermometer was probably 0°·5 lower than the average temperature of the air surrounding the instrument, a correction of — 0°·4 has been applied to its readings instead of — 0°·9, the true correction for index error as determined by Mr. Ellis by direct

comparison with the Kew standard thermometer No. 515, the property of the Royal Observatory.

If the readings of the thermometer be corrected for index errors only, as is the case under ordinary circumstances when observations are made, the difference between the Greenwich and Kew standard barometers is reduced by the amount of ($0^{\circ}5 \times 0\cdot0027 =$) $0\cdot0013$ inch, and the two barometers differ only by the amount $- 0\cdot0001$ inch, that is to say they virtually agree.

In conclusion I would beg to express my thanks to the Astronomer Royal and Messrs. Ellis and Nash for the courteous manner in which they afforded us every facility and assistance in carrying out these comparisons, and to Messrs. Baker, Foster, and Constable for the assistance they have given in the reduction of the observations, as well as in the actual comparisons.

The tables containing the detailed observations are preserved at the Kew Observatory for reference.

NOTE.—Since the effect of the gas burners upon the Greenwich barometer has had attention called to it, Mr. Ellis has fitted opal glass screens between the gas-jets and the barometer. By this means the temperature is rendered much more equable round the instrument.

II. "On the Diurnal Range of the Magnetic Declination as recorded at the Trevandrum Observatory." By BALFOUR STEWART, LL.D., F.R.S., Professor of Natural Philosophy at Owens College, Manchester. Received November 28, 1877.

1. The Observatory at Trevandrum was supported by His Highness the Rajah of Travancore, and its Director was Mr. J. A. Broun, F.R.S., who has recently published the first volume of the results of his labours, giving the individual observations of magnetic declination, and deducing from them conclusions of great scientific value.

Among the other results published by Mr. Broun, are the diurnal ranges of the magnetic declination at Trevandrum, for each civil day in the eleven years, 1854 to 1864. (Table LVIII, page 163.)

In one respect the treatment of the declination observations at Trevandrum differs from that pursued at the Kew Observatory, inasmuch as in the former place, where disturbances are little felt, the diurnal ranges are from all the observations.

The geographical position of the Trevandrum Observatory was as follows :—

Latitude, $8^{\circ} 30' 32''$ N.

Longitude, 5h. 7m. 59s. E. of Greenwich.

A. *Annual Variation of Declination-Range.*

2. The following table exhibits mean monthly results of the declination.

Fig. 1.

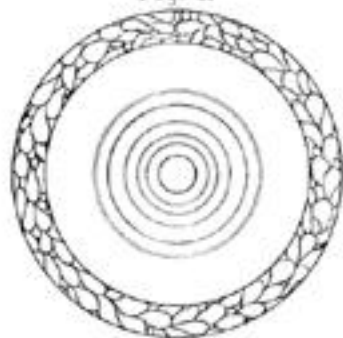


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Fig. 7.

