

of thin solid films are next treated, including Quincke's experiments on the range of molecular action. Chapter ix. is devoted to the behaviour of homogeneous mixtures, both liquid and solid, and chapter x. to heterogeneous mixtures, such as alloys and mixtures of salts. The concluding chapter concerns colloidal solutions, their preparation, structure, &c.

The book, as a whole, is very good. It contains a large fund of information, clearly put and in logical order. It is therefore both readable and instructive.

Aids to Microscopic Diagnosis (Bacterial and Parasitic Diseases). By Capt. E. Blake Knox. Pp. viii+156. (London: Baillière, Tindall and Cox, 1909.) Price 2s. 6d. net.

THIS little book is a *résumé* of clinical methods as applied in the diagnosis of bacterial and parasitic infections of man, and contains a large amount of useful matter in a small space. It is not meant to take the place of the ordinary text-books on these subjects, but to be used for revision purposes, and will be found handy by travellers who are unable to burden themselves with many books. Protozoal organisms, such as malaria, trypanosomes, and spirochaetes, filaria, pathogenic bacteria, and the diseases they cause, pathological secretions, the opsonic index, and vaccine therapy are all dealt with, together with the methods required to demonstrate and isolate the causative organisms.

We have noticed a few slips and omissions, e.g. the *Streptococcus pyogenes* is spoken of as the *S. pyogenes aureus*; no mention is made of the fact that the *Staphylococcus pyogenes* group liquefies gelatin, while the *Staph. cereus* group does not; it is questionable if the tubercle bacillus can ever be detected in the blood; the term "subtertian," now commonly applied to the malignant form of malaria, is not mentioned; toxin and not dead culture is used for the preparation of diphtheria antitoxin; prophylactic vaccination in cholera is given under the heading "serum therapy," &c. Within the limitations stated by the author, we think a useful purpose will be served by this little book.

R. T. HEWLETT.

Lift-Luck on Southern Roads. By Tickner Edwardes. Pp. xv+301. (London: Methuen and Co., 1910.) Price 6s.

HERE is a pleasantly written description of a journey, of some two hundred miles, through five southern English counties, on an unusual plan. Mr. Edwardes says, "My plan consisted in waiting by the roadside or strolling gently onward, until something on wheels, it mattered not what, overtook me . . . by dint of laying under use the whole gamut of country perambulation, at length, after many days of travel, I found myself at my journey's end." Having only a camera and a pack, the author was able to go into every byway he fancied and investigate any subject which presented itself. His account of his wanderings and his illustrations will delight all lovers of the country.

Praeunciae Bahamensis. II., Contributions to a Flora of the Bahamian Archipelago. By C. F. Millspaugh. (Chicago: Field Museum of Natural History, 1909.)

THIS is the second fascicle of a contribution to a flora of the Bahamian Archipelago, issued by the Field Museum of Natural History. It contains observations on old species, the establishment of the new genus *Euphorbiodendron*, and the description of eleven novelties distributed among the genera *Dondia*, *Portulaca*, *Chamaesyce*, *Croton*, *Centaurium*, *Heliotropium*, *Varronia*, *Catesbæa*, and *Callicarpa*, collected in fifteen different islands of the group.

LETTERS TO THE EDITOR.

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Halley's Comet and Magnetic and Electrical Phenomena.

HALLEY'S comet has been a source of interest to magneticians as well as to astronomers. The question was: Would the proximity of the comet's tail occasion a magnetic storm or would it not? If the tail consists of electrified particles, and if it were to envelop the earth, then a magnetic storm appeared a reasonable concomitant. It was thus with some expectancy that I consulted the magnetic curves recorded at Kew on May 19. The conclusion that will be drawn from these and similar records will, I suspect, depend somewhat on the temperament of the inquirer. A large magnetic storm unquestionably there was not, but there was disturbance.

The position may perhaps be best explained by reference to the international lists that are published as to the magnetic character of individual days. Days are classed as "0," "1," or "2," according as they are magnetically quiet, moderately disturbed, or highly disturbed. Taking the three years 1906, 1907, and 1908, the Greenwich and Kew lists, while differing in details, agreed in putting 39 per cent. of all the days in class "0," 58½ per cent. in class "1," and 2½ per cent. in class "2." No day practically is absolutely quiet, and a good many days are so near the line of demarcation of classes "0" and "1" that it is a good deal a matter of chance to which they are assigned. Again, there are an appreciable number of days so near the common margin of classes "1" and "2" that they may well be assigned to either. Thus while the Kew and Greenwich lists for the three years mentioned each assigned twenty-nine days to class "2," only nineteen days were common to both lists. If, then, a day is chosen by haphazard, it is most likely to be of disturbance class "1," while the odds against its being of class "2" are not so great that if it should prove to be of that class one is compelled to accept the coincidence as necessarily more than accidental.

In the present instance what was *a priori* the most probable event has happened; May 19 was undoubtedly of disturbance class "1." So far, indeed, as the declination curve was concerned, the choice between classes "0" and "1" was not very clear, but the horizontal force curve—while very far from being *highly* disturbed—was unquestionably up to the average class "1" level. The most rapid horizontal force changes occurred between 10 a.m. and noon, the range of the largest oscillation being about 50·7 (0·0005 C.G.S.). There were also changes of nearly the same size between 0 and 2 a.m., and again between 3 and 5 p.m. The largest irregular declination movements occurred between 0 and 3 a.m., the range being about 9'. Later in the day there were some oscillatory declination movements synchronous with those shown in the horizontal force curve, but their amplitude was only 2' or 3'.

As a rule, days of class "0" and days of class "1" disturbance occur in groups. The present occasion follows the general rule. From May 13 to 20 no day, except possibly May 16, was of class "0," May 13 being the most disturbed. There were horizontal force changes on the afternoons of May 17 and 18 similar in size to those on May 19. The afternoon of May 20 was also disturbed, though less so. The disturbances on May 18 and 19 were similar in magnitude to those which in 1902-3 accompanied what Prof. Birkeland termed "polar elementary" magnetic storms in the Arctic, and if Prof. Birkeland expected no more than a "polar elementary" storm from the passage of Halley's comet, then I have little doubt that the special observations he has been making in the Arctic will have supplied him with what he was looking for.

As it was conceivable that the intrusion of a comet's tail into the earth's atmosphere might exert a visible effect on the electric potential, I have also examined the Kew electrograms. The electrograms from May 19 to May 20

were throughout their greater part of the usual fair weather type, the potential being neither specially high, specially low, nor specially variable. There were, however, two intervals, between 8.40 and 9.20 p.m. on May 19, and between 1.30 and 3 a.m. on May 20, when there were rapid oscillations and negative potentials, which were not accompanied—as is usually the case—by a rainfall visible in the rain-gauge curves. Thunderstorms were, however, in active progress at the time at no great distance, a good many peals of thunder being audible in Richmond; there was thus nothing in the electrical phenomena that is not adequately accounted for by the observed meteorological conditions.

May 21.

C. CHREE.

The Magic Square of Sixteen Cells. A New and Completely General Formula.

THE ancient problem: *To construct a Magic Square with sixteen consecutive integers*, may be regarded as a special case of the general problem: *To construct a Magic Square with any sixteen positive integers, no two of which shall be identical*. The solution of the problem thus generally enunciated throws much new light upon the ancient special one, and will, in fact, enable us to classify and tabulate its 880 known solutions (8×880 , if we admit reversals and reflections of the same square to be "different") much more scientifically than has hitherto been done.

The following is the completely general formula for the Magic of Sixteen Cells:—

$A-a$	$C+a+c$	$B+b-c$	$D-b$
$D+a-d$	B	C	$A-a+d$
$C-b+d$	A	D	$B+b-d$
$B+b$	$D-a-c$	$A-b+c$	$C+a$

For (1) this formula obviously represents a Magic Square, since every row, every column, and both the central diagonals sum to $A+B+C+D$.

Also (2) it is a function of eight independent variables.

Let S be the sum of our sixteen unknown quantities; then the constant total of the square will $=S/4$. If three of the rows sum to $S/4$, the fourth row must do the same; similarly with the columns.

Hence only eight of the ten given conditions are independent; we have to solve eight simultaneous linear equations involving sixteen unknown quantities. The solution, if general, must thus involve eight arbitrary constants. Therefore the above solution, which does involve eight arbitrary constants, is a perfectly general one.

I proceed to a numerical example. If $A=10$, $B=12$, $C=8$, $D=5$, $a=8$, $b=-9$, $c=-10$, $d=2$, our formula gives us a Magic summing in every direction to 35:—

2	6	13	14
11	12	8	4
19	10	5	1
3	7	9	16

It will be noticed that the number 19 is used, and the number 15 is not.

We have here an example of a Magic in its simplest form, with none of the superfluous (accidental) relations such as appear among the components when those numbers happen to be consecutive; and we see that the "complementary pairs" (each summing to half the constant total) upon which previous writers have laid such stress are a purely adventitious feature, and have no real connection with the laws of construction of the square.

In the fourth volume of the "Récréations Mathématiques" of Edouard Lucas (Paris, 1894) are set out three theorems and three corollaries, enunciating various equalities which must exist between the component numbers of every Magic of Sixteen Cells. The proof of these takes up four pages and a half, and requires twelve illustrative diagrams. My formula proves them all by simple inspection.

If, in the formula, $a=b$, the square assumes the type which Frénicle designated by the letter δ .¹ If $a=-b$, it assumes the type which Frénicle, in his table, left unmarked. Of the latter type, there are exactly 120 in consecutive numbers. I append an example of each type:—

δ			
1	12	13	8
16	9	4	5
2	7	14	11
15	6	3	10

($A=7$; $B=9$; $C=4$; $D=14$;
 $a=6$; $b=6$; $c=2$; $d=4$.)

($A=4$; $B=15$; $C=10$; $D=5$;
 $a=3$; $b=-3$; $c=-4$; $d=1$.)

It must be borne in mind, however, that a complete numerical solution of the δ type necessarily includes the squares which Frénicle marked α and β , because both of these are, algebraically, particular cases of the δ form.

My formula readily supplies an infinity of solutions of the problem, *To construct a Magic Square with sixteen different prime numbers*. The following example (first published by me in the *Pall Mall Gazette* of February 26 last) omits two only out of the first eighteen odd primes, and sums to a far smaller constant than any other investigator has been able to obtain:—

1	47	13	53
61	17	31	5
29	7	59	19
23	43	11	37

($A=7$; $B=17$; $C=31$; $D=59$;
 $a=6$; $b=6$; $c=10$; $d=4$.)

It is obvious that every 4^2 Magic formed by the addition of two Latin squares is divided into equal quarters. No proof, however, has up to now been given of the "converse" of this proposition. I will deduce the theorem from my general formula.

Theorem.—Every 4^2 Magic in equal quarters can be expressed as the sum of two Latin squares.

That the form of the result may be more convenient, I

¹ "Ouvrages de Mathématique." Par M. Frénicle. (La Haye, 1731.)