TRANSACTIONS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR THE YEAR 1874.

SYDNEY: THOMAS RICHARDS, GOVERNMENT PRINTER.

1875.

Royal Society of New South Wales.

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FUNDAMENTAL RULES.

Objects of the Society.

1. The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

President.

2. The Governor of New South Wales shall be *ex officio* the President of the Society.

Other Officers.

3. The other Officers of the Society shall consist of two Vice-Presidents, a Treasurer, and two or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers.

4. The Vice-Presidents, Treasurer, Secretaries, and the six other Members of Council, shall be elected annually at a General Meeting in the month of May.

Vacancies during the Year.

5. Any vacancies occurring in the Council of Management, during the year, may be filled up by the Council.

Fees.

6. The entrance money paid by Members on their admission shall be One Guinea; and the annual subscription shall be One Guinea, payable in advance.

The sum of Ten Pounds may be paid at any time as a composition for the ordinary annual payment for life.

Honorary Members.

7. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or to some other of the Australian Colonies, or distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions, they may attend the meetings of the Society, and they shall be furnished with copies of transactions and proceedings, published by the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

Confirmation of By-laws.

8. By-laws proposed by the Council of Management shall not be binding until ratified by a General Meeting.

Alteration of Fundamental Rules.

9. No alteration of or addition to the Fundamental Rules of the Society shall be made, unless carried at two successive General Meetings.

BY-LAWS.

Ordinary Meetings.

1. An Ordinary Meeting of the Royal Society, to be convened by public advertisement, shall take place at 8 p.m. on the first Wednesday in every month, during the last eight months of the year. These Meetings will be open for the reception of contributions, and the discussion of subjects of every kind, if brought forward in conformity with the Fundamental Rules and By-laws of the Society.

Council Meetings.

2. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Contributions to the Society.

3. Contributions to the Society, of whatever character, must be sent to one of the Secretaries, to be laid before the Council of Management. It will be the duty of the Council to arrange, for promulgation and discussion at an Ordinary Meeting, such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society.

Ordinary Members.

4. Candidates for admission as Ordinary Members to be proposed and seconded at one of the stated Meetings of the Society. The vote on their admission to take place, by ballot, at the next subsequent Meeting; the assent of the majority of the Members voting at the latter Meeting being requisite for the admission of the Candidate.

New Members to be notified of their Election.

5. Every Member shall receive due notification of his election, together with a copy of the Fundamental Rules and By-laws of the Society.

Introduction of New Members to the Society.

6. Every candidate duly elected as Member should, on his first attendance at a meeting of the Society, be introduced to the Chair, by his proposer or seconder, or by some person acting on their behalf.

Annual Subscriptions when due.

7. Annual subscriptions shall become due on the first of May for the year then commencing. The entrance fee and first year's subscription of a new Member shall become due on the day of his election.

Members whose Subscriptions are not paid to enjoy no privileges.

8. Members will not be entitled to attend the meetings, or to enjoy any of the privileges of the Society, until their entrance fee and subscription for the year have been paid.

Subscriptions in arrears.

9. Members who have not paid their subscriptions for the current year shall be informed of the fact by the Treasurer. If, thirty days after such intimation, any are still indebted, their names will be formally laid before the Society at the first Ordinary Meeting. At the next Ordinary Meeting, those whose subscriptions are still due will be considered to have resigned.

Expulsion of Members.

10. A majority of Members present at any ordinary Meeting shall have power to expel an obnoxious Member from the Society, provided that a resolution to that effect has been moved and seconded at the previous Ordinary Meeting, and that due notice of the same has been sent in writing to the Member in question, within a week after the meeting at which such resolution has been brought forward.

Admission of Visitors.

11. Every Ordinary Member shall have the privilege of admitting one friend as a Visitor to an Ordinary Meeting of the Society, on the following conditions :—

1. That the name and residence of the Visitor, together with the name of the Member introducing him, be entered in a book at the time.
2. That the Visitor does not permanently reside within ten miles of Sydney, and,
3. That he shall not have attended two Meetings of the Society in the current year.

The Council shall have power to introduce Visitors, irrespective of the above restrictions.

Management of Funds.

12. The funds of the Society shall be lodged at a Bank, named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

Audit of Accounts.

13. Two Auditors shall be appointed annually, at an Ordinary Meeting, to audit the Treasurer's Accounts. The Accounts as audited to be laid before the Annual Meeting in May.

LIST OF MEMBERS

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Royal Society of New South Wales.

Adams, P. F., Surveyor General.
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Fairfax, John, *Herald* Office.
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Neill, A. L. P., Esq., City Bank.
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Owen, the Hon. Robert, 88, Elizabeth-street.

Paterson, Hugh, Macquarie-street.
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Reed, Howard, Potts's Point.
Renwick, Dr. Arthur, Elizabeth-street.
Roberts, J., George-street.

Roberts, Alfred, Phillip-street.
Robertson, Thomas, M.P., care of M'Carthy & Robertson, Pitt-st. N.
Rogers, Rev. Edward, Fort-street.
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Watt, Charles, Parramatta.
Watt, J. B., Esq.
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Weigall, A. B., Head Master, Sydney Grammar School.
White, Rev. James S., M.A., LL.B., Gourie, Singleton.
Wilkinson, C. S., Esq., Geological Survey Office, Department of Mines.
Williams, J. P., New Pitt-street.
Wood, Harrie, Department of Lands.
Woodgate, E., Esq., Parramatta.
Wright, Horatio G. A., Wynyard Square.

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DUPLEX TELEGRAPHY.

By E. C. Cracknell, Esq., Superintendent of Electric Telegraphs.

[*Read before the Royal Society, 20th May, 1874.*]

Duplex telegraphy, as it is now called—that is, working in two opposite directions on one wire simultaneously—was first tried by Dr. Gintl, the Director-General of Telegraphs in Austria, on a line from Vienna to Prague, as far back as 1853. The relays of the instruments were wound with two wires, so that the transmitting station could work the relay at the distant station without affecting the instrument at its own end of the line. This was managed by a battery for the line wire of the ordinary type, and an equating battery for the second relay wire; but the compensating currents could not well be controlled, and the system was not found to be a practical success, although experimentally it worked beautifully. In 1854, Frischen, Siemens, and Halske devised a modification of the duplex working by adopting a somewhat complicated system of resistance coils, but discarded the counteracting batteries: these were the first Morse instruments used on the telegraph lines in this Colony between Sydney and South Head, in January, 1858, but were found unworkable, and were reduced to single-acting Morse recorders. Siemens and Halske's arrangement was worked on what is called the differential principle, that is, if two circuits of equal resistance be open to a current, it will equally divide; but by placing unequal resistance in the two circuits the greater portion of the current will pass through that having the best conductor; there is then one main circuit through the line, the other a derived circuit through the resistance coils. If the key at the sending station A be pressed, the current divides—one portion proceeds through the line and moves the armature of the relay at the distant station B, the other portion proceeds through the compensating wire and resistance coils to earth; now these currents being equal at the sending station, they have no tendency to move the tongue of the relay at A, which is ready to receive the current from B. Suppose the resistance at A is less than that of the line, then the current passing through the compensating circuit will be greater than that passing by the line, so that, by pressing the transmitting key, signals will be made at the sending station which would prevent the receipt of perfect signals from the distant station, and would prove that the instrument was not in proper adjustment. To overcome this difficulty, the resistance must be gradually increased until the two currents are equalized so that the closing of the key has no effect on the armature of the relay, and no signals are made except at the distant receiving station. It is therefore evident that when station A is sending to station B, A's relay is unaffected, while the relay at B will be made to work and the instrument record A's signals, and *vice versa.* Stern's duplex system, lately perfected in America, and now daily attracting the attention of telegraph engineers in most parts of the world, is on a principle which is dependent on producing an equality of tensions which are sometimes called potentials; but to be more explicit to those who have not studied the science of electricity, it is, according to Jenkin, the difference of electrical condition in virtue of which work is done, by moving from a point at higher tension to that of a lower; or perhaps Mr. Preece has made it clearer by calling it an analogous term to pressure, as applied to fluids and gases. With this system the relay coils are also wound with double wires; it has proved a great success, partly by improvements on old principles, but more particularly in consequence of the introduction of more perfect appliances since Gintl's, and Siemen's, and Halske's inventions. The arrangement before you this evening is perhaps the most simple duplex working apparatus yet devised; the two instruments are the ordinary Morse recorders with relays in every-day use on the lines in this Colony. The relays are wound with one continuous wire, and the only additions are the two vertical water columns for producing the necessary artificial resistance for dividing the currents; the actual line resistance being equal to 150 miles of wire.

With this plan only one battery is employed for the line circuit which is continuous, that is, in one direction, and the adjustment requires very little attention. It must not be understood that two distinct currents of electricity pass in opposite directions through one line of wire at the same time; but the problem has been solved by increasing the amount of current on the main circuit when signals are sent simultaneously. Although duplex telegraphy may now be considered beyond a doubt as to its practicability, we are not likely to remain satisfied with its success for any lengthened period. Mr. Meyar's ingenious invention of the multiplex telegraph, exhibited in the late Vienna Exhibition, bids fair to eclipse all the telegraph instruments now in use for rapidity of signalling through one wire. This instrument has already been tried between Paris and Lyons, with four transmitters on one line, and 100 to 120 messages of average length are sent through per hour.

HOSPITAL ACCOMMODATION.

By Alfred Roberts, Esq., M.R.C.S.

[*Read before the Royal Society*, 1*st July*, 1874.]

I am again indebted to the kindness of the Committee of this Society for permission to bring under your consideration a subject which belongs more strictly to the sphere of social than of general science.

I have, however, always entertained an opinion, which increases with experience, that such topics are of vital importance to all Committees, and more especially so to those of young Countries, where as the seed is sown will the harvest follow.

The present position of the hospital question in Sydney is both critical and important, demanding the earnest consideration of all who take an interest in this branch of charity, and calculated to induce those possessing special opportunities for observation to offer their experience for the review of others.

The subject has, moreover, an additional interest at the present time, when a week hardly passes in England without the publication of anxiously thoughtful pamphlets and reviews founded upon the startling disclosures made through the labours of the newly established "Charity Organization Society," and the reports of the Committee of the Hospital Sunday Fund, &c.

The inquiries of these useful Associations have proved, beyond doubt, that the present system of administering "medical charity" has resulted in its rapid and inconsistent increase in the most wealthy cities of England, and in an extravagant expenditure.

For instance, we find that in Manchester, during the year 1836, the recipients of medical charity were in the proportion of one to every eight of the population, but in 1872 the proportion had risen to "one" to "five." In London, at the present date, no less than 30 per cent. of the population are recipients of gratuitous medical aid, the funds for which are raised by voluntary subscription. In Manchester the amount thus raised would, if distributed among the recipients, give to each four shillings and fourpence-halfpenny. In London it would yield ten shillings to each of the more numerous recipients.

I must, however, refer those who feel interested in the instructive details of this important inquiry to two admirable articles in the *Westminster Review* for January and April, and the *Quarterly Review* for April of this year. I will only now quote one additional fact in support of the conclusions above mentioned, and as affording evidence of a demoralizing spirit similar to that which, I regret to feel, already exists among certain classes of our young and otherwise prosperous community.

"Four years ago an attempt was made to induce the men of a large manufacturing firm in the metropolis to add something from themselves to a subscription of fifteen guineas per annum already given by the firm to a neighbouring dispensary; the whole of the letters given for this amount being constantly in use, and many more being required. It was found that a penny a month, from little more than half the men at work, would raise the subscription to forty guineas per annum, which would entitle them, according to the published scale, not only to as many tickets as they could require for themselves and families, but also to a certain number for their friends.

"Notwithstanding these advantages, the subscription was started with considerable difficulty, and the collection of pennies became gradually so irregular and unsatisfactory that at the end of two years and a half it had to be entirely dropped, a small balance of the subscription for 1871 and '72 still remaining unpaid. It thus appears that a farthing a week was considered too heavy a charge for medical attendance and medicine, not because they were not wanted, for the full complement of letters was in constant requisition, nor because a penny a month could not be afforded by each man, but simply because every trace of the principle of independent self-help had been undermined and abolished by the facility presented to the men of getting what they needed at other people's expense."

I take the following, as one of many similar examples which might be quoted, from the Second Report of the New South Wales Charity Commission recently issued, page 73. Speaking of out-door relief as administered at the Benevolent Asylum, it says:— "The imposition which is practised on the institution arises not so much from persons applying who are not entitled to relief in the first instance, but chiefly in cases where a husband is sick in the Infirmary, and the family require relief and get it, and then the husband gets well and goes to work, and the family still continue to receive the relief, and after a time the circumstances are discovered. The evidence is that in such cases there is scarcely one in a hundred who has the honesty to say I do not require the relief any longer."

Thus it appears that the results of wholesale and indiscriminate medical charity tend to increase the number of its recipients and the cost per head, as well as to induce general pauperism.

If such evils have accrued in a Country like England, during a period when money was more scarce than it now is, from a disregard of the true principles which should guide the distribution of charitable funds, surely it is important in a young Country, where wages are high, the necessaries of life cheap, and the climate genial, that we should consider well if it is not possible, on the one hand, to afford full relief to the truly necessitous, and, on the other, to avoid offering temptation to any to forfeit their independence. Blind charity—that which is shown by the pecuniary gift, rather than the hearty desire to co-operate with the distressed and assist them to retain their self-respect—discourages thrift and helpfulness, and generates the spirit of dependence, which is the chief source of pauperism.

With these preliminary remarks, I will proceed to the immediate subject of this paper, and in doing so will confine myself as much as possible to general hospital accommodation, assuming that hospitals for special diseases are as a rule undesirable, as equally injurious to the cause of charity and the science of medicine.

In approaching our subject, it is necessary to bear in mind the difference between the position of London and Sydney in relation to medical charity; otherwise, in our endeavour to gain information from the experience of our Parent Country, we may be led astray.

The differences are these: In Sydney we have no organized Poor Law relief; in Sydney wages are much higher; in Sydney the various Benefit Clubs have assumed a more healthy tone and form, and are far more numerous.

In the full (and in many respects excellent) Report of the Charity Commission, there is an earnestly expressed opinion that the main front and outbuildings of the Sydney Infirmary should be taken down—a recommendation, it is but fair to add, which was made by a Committee of the Directors of that institution, and adopted by them, as long back as March, 1868.

The Directors of the Prince Alfred Hospital, after much anxious deliberation, entered upon with a firm desire to utilize the fund in strict accordance with the intentions of the subscribers, as expressed in the original resolutions, have determined to plan a large and complete Hospital and Medical School, and to erect a portion of it at once. This scheme has been sanctioned by the Government, which has devoted by Act of Parliament eleven acres of the University ground to the purposes of the future hospital. The plans of two ward pavilions, each of which will contain sixty-three beds, are nearly complete; and it is in contemplation to commence them as soon as possible.

Taking it for granted, therefore, that the Infirmary buildings must be presently removed, it is evident we are about to re-organize and construct anew the hospital accommodation of Sydney, except that provided by St. Vincent's Hospital.

What shall be the form, position, and extent of the accommodation, and how shall it be organized, how supported? These are the questions which demand inquiry and the prompt decision of Government, in order that each may work in harmony with the rest, to one centre of good.

The principle upon which our hospital accommodation should be established may be described as that by which it can be provided of the most complete form, of the required extent to meet existing demands, and be capable of systematic progressive increase to fulfil the requirements of the future. It ought not, however, at any period to be much in excess of the demand, neither should the cost of its original construction or annual support exceed the smallest amount for which these can be efficiently provided.

With these principles for our guide we have to consider—

1stly. What is the character, extent, and current expenditure of our existing hospital accommodation?

2ndly. What are the present and probable future requirements of the community in respect to this?

3rdly. What are the best means of dealing with the existing accommodation, with a view to removing its defects, and supplementing it to meet the demands of the future?

In the course of this inquiry it will be necessary to speak of some of the benevolent asylums, but only to such an extent as they bear upon the subject of hospital accommodation.

For a full description of these establishments I must refer you to the excellent Report of the Charity Commission. It will be sufficient for our present purpose if I briefly mention those at Liverpool, Parramatta, and Hyde Park.

The Liverpool Asylum is in many respects a good and substantial institution, and in all, a model of good management; but, with the exception of the new wing, it possesses no special accommodation for hospital cases. I should like to add another word in praise of an institution which appears to me an example to most others which I have seen in the Colony. Having recently visited several of the best establishments in Europe of a similar character, it affords me pleasure to say that I cannot call to mind any in which more was accomplished with the means at the disposal of the officers.

The Asylum at Parramatta consists of several buildings, all of which are very old and many in very bad repair. It was never adapted to the purposes for which it is now used, more especially as a home for aged invalids or hospital cases. The mangement is the converse of that of Liverpool, though both establishments are under the same Board.

Hyde Park Asylum is clean and well ordered, "but is very much too confined for the purpose to which it is devoted, and its position within the city is unsuitable. No room exists for the reception of cancer and other cases, often received from the Infirmary, the presence of which is distressing to the other inmates." *

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* Charity Commission's Report.

The accommodation provided in these Asylums is devoted to the reception of cases of destitution arising from advanced age, impaired constitution, or illness of a confirmed, chronic, or incurable nature.

On the 31st December, 1873, they contained the following accommodation:—Liverpool Asylum, for 650 men; Parramatta Asylum, for 240 men; Hyde Park Asylum, for 230 women. Total, for 890 men and 230 women.

The number of inmates remaining in the respective Asylums on 31st December, 1873, was as follows:—Liverpool.—General inmates, 423; hospital cases, 193. Parramatta.—General inmates, 229; hospital cases, 45. Total men, 890. Hyde Park.—General inmates, 190; hospital cases, 28. Total women, 218.

In calculating this accommodation the amount of cubic space allowed to each inmate has been put as low as possible compatible with health, and considerably below what is thought necessary in England. Probably in this climate a space of about 650 cubic feet may be considered enough for the general inmates, who do not occupy the rooms during the day, but the hospital wards should undoubtedly have from 900 to 1,000 feet. Yet it has been no uncommon thing for these institutions at times to contain a much larger number of inmates than above stated, and thus, of course, to have been overcrowded.

To the figures above given it is necessary to add those for accommodation provided during the present year. This consists of a new wing at Liverpool, intended for 170 hospital beds, and a building at Hyde Park, not new, to receive 35 inmates.

There is, therefore, total accommodation at the present time for 1,060 men and 265 women.

The number of inmates at the present time is about 900 men and 230 women, showing a surplus of 95 beds to meet future demands, if the wretched buildings at Parramatta are retained as an Asylum.

We possess two Hospitals—St. Vincent's, and the Sydney Infirmary.

St. Vincent's is a good modern and substantial structure, under the management of a lady superior. It has building accommodation for about ninety beds, of which a part only is occupied at present, containing thirty-six beds. Hopes are entertained that before the end of this year the fund will be sufficient to furnish and occupy twenty-four more.

In addition to the above, there are six private wards, which are generally full, and the occupants of which pay three guineas a week.

This hospital is devoted to cases of serious disease and accident.

The Sydney Infirmary contains 228 beds, of which seventy-seven are in the back south wing, and 151 in the main building, which faces Macquarie-street. The south wing is an excellent, substantial hospital pavilion, but unfavourably situated, in its close proximity to the high wall which separates the grounds of the Mint from those of the Infirmary; the two floors are isolated by means of an outside detached staircase, and the bath-rooms, lavatories, &c., are well arranged. The ground in front of this building and opposite the back of the main front building is often swampy and unwholesome, but this latter point could easily be rectified. A very large average of erysipelas occurs in this wing. The main front building is very old, very much out of repair, and undoubtedly very unhealthy. The latter characteristic has I fear caused the loss of many valuable lives, and cannot, in my opinion, be got rid of without taking down the building and exposing the foundation soil to the wind and sun.

The rules of the Infirmary are good, and it is most desirable they should be strictly carried out. It is evident from the nature of those regulating the admission and discharge of patients that the institution is devoted to the treatment of serious disease and accidents. Moreover, no patient can remain for more than eight weeks, unless it is certified at a consultation of the honorary physicians and surgeons that the disease demands longer treatment in an institution of this character.

Until last March this rule had, from various reasons, remained a dead letter, and an average of from fifty to eighty beds have always been occupied by patients to whom justice could have been done in a hospital of a far less expensive character. In March it was found possible to act upon this rule, and fifty patients were discharged. Monthly consultations of the staff are now held, at which all patients whose residence in the institution has exceeded eight weeks are examined, and such only are retained as appear to require the special facilities of treatment afforded by the institution.

The result of carrying out this rule has had a very marked effect upon the accommodation available for the daily admission of patients, as we shall find hereafter.

Thinking it possible that the discharge of so many cases at one time from a hospital might have been attended with possible suffering and hardship, I made inquires into the question, and ascertained from the Manager of the Infirmary that no complaints of any kind had come to his knowledge, but that one of the patients so dischargd had been re-admitted. From the Secretary of the Asylum Board I learned that the average admissions for the three weeks following the consultation alluded to, at which fifty patients were discharged, had only been very slightly exceeded, perhaps by two or three.

On this occasion, therefore, nearly fifty patients who had occupied beds, some of them for many months, were able to find homes and support, and preferred to do so to entering the Liverpool Asylum. Medical treatment they could obtain from the Dispensary.

We have now to ascertain whether the small proportion of those discharged and who elect to go to the Liverpool Asylum suffer or benefit by the change from an institution in which the cost of each bed is £45 per annum, to another in which it is £12 14s. To ascertain this point, Mr. Frederic King was kind enough to write to Dr. Strong, the able Superintendent of the Liverpool Asylum, and submit to him the following questions from me.

The questions, with Dr. Strong's reply, are as follows:—

"QUESTIONS.

6. "Number of persons who, having been recently discharged from the Infirmary at the time of their admission into the Asylum, and suffered in consequence from the change from the one institution to the other, during (say) tho two and a half years ending June 1, 1874?

7. "Number of persons who, having been recently discharged from the Infirmary at the time of their admission into the Asylum, and benefited in health from the change from the one institution to the other, during (say) the two and a half years ending June 1, 1874?"

"REPLY.

"Liverpool Asylum,
"14th June, 1874.

"In reference to the questions (Nos. 6 and 7) asked by Dr. Roberts, I may remark that I cannot speak positively to either.

6. "I think I am correct in stating that during the last two years and a half ending June 1, 1874, the average number of patients received from the Sydney Infirmary has been two per week, and I am certain that I am within the average. I have at present in hospital some twenty or more, direct from the Infirmary. The number of those discharged from the Infirmary, and for some reason have remained in Sydney for a day or two, and then have been sent here, far exceed the above average.

7. "My answer to this must be amalgamated with the above; for, not taking any particular interest in the place from which the several patients may come, unless the case may present some particular features of interest, my memory will not bear me out as to the exact benefit each Infirmary patient may have received; but I should say that quite a third have been benefited by the change, and have been discharged cured, or in a position to earn their living outside, or have taken different places in the institution, whereby they make themselves useful and earn a few shillings.

"Almost in every case a temporary beneficial change takes place from the removal from one institution to the other, the permanency of which, of course, depends upon the nature of the disease: malignant disease—phthisis and such like—do not improve permanently. I may say that I have never known any immediate injury incurred by the removal from Sydney to this place of any sick person.

"W. E. Strong, M.D.,
"Fred. King, Esq." "Surgical Superintendent."

Thus it appears that from fifty to eighty beds have until recently been occupied by patients who either possessed homes where they could have been treated as out-patients, or were received into one of the Asylums where they were treated and lodged without suffering in health from the change—some, indeed, benefiting by it.

Let us take the medium number of sixty-five of such patients as a fair average; probably ten of these, certainly not more than fifteen, would enter one of the Asylums; the saving, therefore, in one year would amount to £2,925, calculated at £45 each; but from this we have to deduct the cost of the fifteen patients who go to the Asylum at £12 14s. each—say £200, leaving a balance of saving of £2,725 for one year. If we carry this back only ten years, we have an approximate estimate of no less than £27,250 that might have been saved; or, to speak perhaps more correctly, that would have been available for the treatment of patients to whom justice cannot be done at a less cost than £45 per annum.

The following table, prepared from statistics kindly furnished to me by the Committee of the Infirmary, may be found useful:—

	January.	February.	March.	April.	May.	June.	Year.
Total number of vacant beds each month	200	161	217	433	218	297	1873
Total number of vacant beds each month	68	95	398	733	794	790	1874
Total number of patients admitted each month	183	164	159	158	166	126	1873
Total number of patients admitted each month	192	174	184	173	187	183	1874
Monthly surplus of vacant beds	17	—	58	275	52	171	1873
Monthly surplus of vacant beds	124	—	214	555	607	607	1874
Average number of beds vacant daily in each month	$6\frac{1}{2}$	$5\frac{3}{4}$	7	$14\frac{1}{2}$	7	10	1873
Average number of beds vacant daily in each month	$2\frac{1}{4}$	$3\frac{1}{4}$	$12\frac{1}{2}$	$24\frac{1}{2}$	$25\frac{1}{2}$	$26\frac{1}{3}$	1874
Average number of patients admitted daily for each month	6	6	5	5	$5\frac{1}{3}$	$4\frac{1}{4}$	1873
Average number of patients admitted daily for each month	6	6	6	6	6	6	1874

Reference to this table shows that from January 1st to July 1st, 1873, there was a total of 1,526 vacant beds and 956 admissions, showing an excess of vacant beds over admissions of 570, or about 3 1-7th daily.

Taking the same period of the present year, we find a total of 2,878 vacant beds against 1,098 admissions, showing an excess of 1,780 vacant beds, or about $9\frac{3}{4}$ daily.

But if we take the number of vacant beds and admissions from the 1st of March to the 1st of July in each of the same two years, that is, during those months in which, this year, all patients were discharged whose further detention in the hospital was considered undesirable, we shall find the figures more disproportionate still:—

Vacant beds from 1st March to 1st July, 1873...	1,165
Admissions, ditto ditto, 1873	609
Surplus of vacant beds, ditto ditto, 1873	556
Vacant beds from 1st March to 1st July, 1874 ...	2,715
Admissions, ditto ditto, 1874	732
Surplus of vacant beds, ditto ditto, 1874	1,983
Daily average of surplus vacant beds, 1873 ...	$4\frac{1}{2}$
Ditto ditto ditto, 1874	$16\frac{1}{4}$

Another point that deserves attention is the great similarity between the numbers of the admissions during each month of the two years, a feature which is more evident on looking at the monthly daily average.

The proportion of vacancies to accommodation appears to be rather more than 10 per cent. in the two hospitals, and this average would undoubtedly be increased by the establishment of a chronic hospital. We will however take it at 10 per cent.

There are 228 beds in the Infirmary, and thirty-six (to be increased this year to sixty) in St. Vincent's Hospital, making a total of 288. These would yield a daily average of nearly twenty-nine beds, to meet a demand which the statistics prove has not hitherto exceeded an average of seven (and during 1873 was under six), judging by the test of admissions.

It must, however, be borne in mind that a margin of empty beds to the extent of about 5 per cent. should be allowed for cleansing and disinfecting—for bed spaces to be left vacant a certain time after cases of fever, for unavailable beds arising from the necessary classification of patients, &c.

A summary of the last-mentioned facts would stand thus :—

Daily average of vacant beds at ten per cent. on 288 beds, say	28
Deduct five per cent. for administrative purposes, say ...	14
Deduct also for the average supply of suitable cases for admission, say	7
Total	21

Giving a daily surplus of empty beds to meet emergencies and increased demand of seven, a number equal to the total number of the present admissions.

It further appears that with a fewer number of occupied beds a larger number of patients were admitted and discharged during the first six months of 1874 than 1873, proving that the retention of the chronic and incurable cases has been prejudicial to the interests both of the sick portion of the necessitous class and to the valuable working of the institution.

To ascertain whether the health of the poor had been materially different in these two years, I inquired at St. Vincent's Hospital what the admission had been in the first five months of 1873 and 1874 respectively. I was informed that exactly 135 patients had been received in both years, and further, that they did not hesitate to put up extra beds if much required.

The conclusions to which these investigations lead are—

1. That the amount of accommodation at present contained in the hospitals already existing in Sydney would, if strictly devoted to cases of serious disease and accident, be sufficient to meet the present demands of the community, but (as will be shown hereafter) is incapable of that progressive expansion demanded by a rapidly increasing community.
2. That accommodation for persons suffering from chronic and incurable disease and for convalescing patients only exists to a very limited extent, and that of an objectionable character as being in a poor-house.
3. That the accommodation contained in the main front building of the Infirmary, amounting to 151 beds, is proved by the evidence taken before the Charity Commission to be so unhealthy and unsatisfactory in character as to demand its immediate removal.

I have now to state what I believe would be the cost for original construction and subsequent annual support of the two forms of hospitals, and of the different schemes open to our selection.

Having recently been compelled to go carefully into the cost of hospital construction in Sydney at the present time, I feel justified in giving the following figures as approximately correct:—

1. For a large hospital efficient in all respects for the treatment of serious cases of all kinds, and for the purposes of a medical school, £250 to £350 per bed, irrespective of the cost of site.
2. For a large hospital suitable for chronic cases, &c., £60 to £90 per bed, irrespective of site.

After a careful examination of the question of hospital current expenditure in Europe, and a rather long experience in Sydney, I am satisfied that this will not amount to less than from £45 to £50 per bed in hospitals devoted to serious cases and in which justice is done to them.

At St. Vincent's the cost is much less than this, but this case is exceptional, and much to the credit of the benevolent lady at the head of it.

A hospital for chronic and incurable patients, &c., ought certainly to be managed at an annual cost per bed of from £16 to £18.

The last figures given are somewhat higher than some of my most experienced friends consider necessary; but I am anxious not to understate the probable cost, and feel also it will be true economy to render such an institution capable of receiving the largest possible proportion of cases, if only to relieve the central general hospitals.

A consideration of these statistics and general experience naturally leads to the conclusion that the *character* of our present and probable future requirements in respect to hospital accommodation may be described as follows:—

1. To provide accommodation of a suitable character for the reception, as in-patients, of all cases of serious disease and accident, and to afford clinical instruction to the pupils of a University School of Medicine.
2. To provide suitable accommodation for the reception, as in-patients, of all cases of confirmed chronic and incurable disease, and for a certain number of convalescing patients.

Humanity and reason equally demand that the accommodation for the first class should be provided in a hospital possessing all the appliances suggested by modern science, and therefore comparatively expensive; and that for the second class, in one, simple and economical both in its construction and current expenditure—calculated also to prepare its inmates to resume, without detriment, the habits of their home life. The more perfect the first, the more rapid will be the recovery of the patients, and the smaller the mortality; the more simple the latter in structure and management, the more will the habits and health of its inmates approximate to what is required to fit them for a life of industry, &c.

The first or general hospital should, when possible, be placed in a suburban position, but easy of access. The site should be healthy, and free from all possible encroachments of neighbouring buildings, and adapted to the purposes of a medical school.

It should, further, possess a branch, in the form of a small receiving hospital, situated in the centre of population, for the reception of bad accidents and other serious cases such as could not safely be removed at once to the general hospital. This branch establishment should be limited in accommodation to the smallest number of beds required for the purpose.

The arguments in favour of these have been so often put forward that I need not refer to them further now.

The necessity for the immediate establishment of a hospital for chronic cases, &c., may be recognized upon the following grounds:—

Firstly. That an asylum or poor-house is only suited for the reception of a certain proportion of the patients who do not require to be treated in a general hospital; and that to send the others to a poor-house, even if they are willing to go, has a demoralizing influence.

Secondly. That it is in the highest degree desirable to make the proportion of patients to be treated in the general hospital as small as possible; and that it is impossible to attain this end unless a suitable institution exists to which they can have the option of going, and where it can be felt they will have the care and treatment required,

Thirdly. That the present surplus accommodation at the Liverpool Asylum will it is evident be soon required to meet the demands of the steady increase of paupers, and that a certain proportion of temporary invalids will always exist in such an establishment, for whom the hospital wards will be required.

Fourthly. That experience shows it is undesirable to establish convalescent wards in a general hospital, where a certain number of men will always be found to remain who would return home to work rather than be sent away from Sydney.

A Chronic Hospital should be placed upon a healthy site, at a certain distance from town. If upon the line of railway, it should not be nearer than Homebush or more distant than Prospect. If upon the high ground of the North Shore, it need not be so distant. If too far away, it would be beyond effective supervision, and the distance would be inconvenient to the patients; if too near, the beneficial influence of change would be less upon the invalids.

It should possess ample grounds, and be built in pavilions of simple construction. A small amount of administrative accomodation would be required, and it should be conducted upon the most economical principles.

Accommodation would in the first instance be required for 300 beds for men and 100 for women, of whom I imagine the Asylums would at once contribute at this time about 230 men and thirty women.

Such a hospital could be enlarged from time to time as further accommodation was required; but whatever scheme is adopted in regard to the central General Hospitals, this, the Chronic Hospital, should be erected *at once*.

In 1870, I drew the attention of Government to the fact that the Victoria Barracks were unoccupied, that a hospital for chronic cases was much required, and that the barracks were suited to the purpose. If these buildings were still unemployed, I should, for economical reasons, suggest that they might be thus utilized at the present time; but as they are now occupied, and contemplating a general scheme as we are now doing, it is our duty to consider which is the best, and as such, we can have no hesitation in acknowledging that the Chronic Hospital should be placed out of Sydney.

We have next to consider how these principles can be carried out in the most efficient manner under existing circumstances, and in doing so we have to bear in mind that the demand for beds during the last two years has been met by the daily average of vacant beds arising from a total of 264, and that in future St. Vincent's Hospital will supply at least sixty.

The following schemes are open for our selection:—

1st. That towards which we appeared to be drifting, and the serious evils of which have induced me to trouble you with this paper.

The front Infirmary buildings to be rebuilt, and the Directors of the Prince Alfred Hospital to be left to put up a couple of pavilions, without information as to the manner in which our hospitals are to be arranged, organized and supported.

This plan would afford, in the first instance, about sixty beds—more than would be required; and the two hospitals would be rivals in the competition for patients and funds.

The Medical School being at the University, great inconvenience would arise from the students having to attend two hospitals, the most distant of which from the University would, from its central position in the city, possess the most serious cases of disease and accident.

Two Boards of management would be in existence, and two administrative establishments, with their respective officers, would be required for a number of patients which could be managed with more efficiency and economy by one.

The current expenditure of hospitals is proportionately greater in the small than in the large, but this would probably be counterbalanced in some degree by the distance of the Prince Alfred Hospital from town, and by the much greater perfection of its arrangements.

The following table shows the cost, accommodation, &c. :—

SCHEME A.

	Beds.	Cr. £	Dr. £
Rebuilding the front and outbuildings, &c., of Sydney Infirmary	177	...	30,000
Building two pavilions of the Prince Alfred Hospital	128	...	24,000
Ditto administrative block		...	20,000
St. Vincent's Hospital	60	...	......
Prince Alfred Hospital Fund		24,000	......
Required from Government		50,000	......
Total beds...	365	£74,000	£74,000

Surplus beds over present demand, about 85.

2nd. The Directors of the Prince Alfred Hospital might obtain from the Government a sufficient sum to enable them to put up the administration block of the hospital at the same time that they erect the two front pavilions—these would constitute a working establishment for 128 beds, into which, when finished, the patients could be removed from the front building of the Sydney Infirmary. That structure would then be taken down, a new kitchen, mortuary, &c., be erected, and the centre space drained, laid out, and planted, down to the Domain wall.

Under this plan the south wing would serve as the receiving hospital, one floor being devoted to men and the other to women; it is larger than is necessary for this purpose, and the proportion between the sexes is unsuitable. A large and very valuable piece of ground would be devoted to a purpose for which a smaller piece in another position would answer.

This plan would yield 207 beds, which with sixty in St. Vincent's would meet present requirements, and the Prince Alfred Hospital would be capable of enlargement from time to time, but it would be open to the before-mentioned fault of having two establishments.

The Nightingale wing, being larger than is necessary for the purposes of such an amount of ward accommodation, should be converted into a training-school for supernumerary nurses, to go out on hire, or for employment in country hospitals; indeed, the training of such persons should be provided for in any scheme that is adopted.

The following table shows the cost, accommodation, &c.:—

SCHEME B.

	Beds.	Cr. £	Dr. £
Building a new kitchen, mortuary, &c., laying out grounds of Infirmary for south wing to serve as a Receiving Hospital, &c.	77	......	7,000
Building two pavilions of the Prince Alfred Hospital	128	......	24,000
Building administration block	...	......	20,000
St. Vincent's Hospital	60	......	......
Prince Alfred Fund	...	24,000	......
Required from Government	...	27,000	......
Total beds	265	£51,000	£51,000

3rd. Sufficient pavilions of the Prince Alfred Hospital to contain 200 beds with the administration block might be built at once, and at the same time a Receiving Hospital to contain thirty beds might be erected on the Flagstaff Hill, or other convenient site, to accommodate twenty men and ten women. When these were complete, all the patients could be removed from the Infirmary, and the Government resume the land and buildings, the latter of which would make reasonably good Public Offices, though unhealthy for hospital purposes.

This plan offers the following advantages:—All the money would be expended in the erection of new substantial buildings of modern arrangement, and on good sites. The management would be central, there would be no rivalry, and thus it would be easy to render one officer responsible that no really necessitous person whose disease required hospital treatment was refused, and that all who could afford to pay should, if admitted, be compelled to do so in proportion to their means.

The accommodation would be capable of systematic and economical increase from time to time, and would be of the kind most favourable for the students of a medical school.

It would thus, and only thus, be possible to erect a noble and complete hospital, in which the patients could be properly classified, and of which the metropolis could be proud.

The receiving hospital would occupy its correct position as a branch institution under the same management.

The following is an approximate estimate of the original cost:—

SCHEME C.

	Beds.	Cr.	Dr.
Prince Alfred Hospital administrative block and pavilions complete for	200	......	£61,000
Receiving Hospital complete for	30	......	9,000
Including value of site	...	......	5,000
Amount of Prince Alfred Hospital Fund	...	£24,000	......
Value of land in Macquarie-street—Infirmary site	...	36,000	......
Value of Infirmary buildings	...	13,780	......
		£73,780	£75,000
St. Vincent's Hospital	60		
Total beds	290		
Balance required from Government, for which value is not received		1,220	
		£75,000	

N.B.—The estimate of the value of the Infirmary site has been most kindly furnished to me by Messrs. Richardson and Wrench. The estimate of the buildings is taken at the original cost of the Nightingale Wing and South Wing only.

This paper has already far exceeded the limits to which I had originally designed it, and it will be impossible for me to deal with the important questions of organization and support.

I will, however, close my remarks by enumerating some of the points which occur to me as requiring full consideration and prompt decision.

1. Whether our hospitals should not be open to every sick person in necessitous circumstances, subject only to the fitness of his case for treatment?

2. Should not our hospitals—the general, the receiving, and that for chronic disease, &c.—be under one organization and management?

3. What proportionate voice in the management should the Government possess?

4. Upon what principle and to what extent will it be desirable that the Government should contribute to the funds for original construction and current expenditure?

5. Should not the provident spirit and system be fostered and adopted to the fullest extent?

6. May or may not medical clubs be made to pay for members in hospital?

7. Should not the dispensary system be much extended, and separated from the hospitals, in management, &c., the latter reserving the right of having an independent out-patient department when required for students, &c.?

Other points will develop themselves as the subject is discussed; in the meantime, the above suggestions will indicate how much remains to be done in a subject of great social importance.

ALFRED ROBERTS.

CRIMINAL STATISTICS OF NEW SOUTH WALES, FROM THE YEAR 1860 TO THE YEAR 1873.

By Christopher Rolleston, Esq., Auditor General.

[*Read before the Royal Society, September* 23, 1874.]

Mr. Christopher Rolleston read the following paper "On the Criminal Statistics of New South Wales," explaining at the outset that it was merely a fragmentary insight into statistics of crime. At first he intended to have made a perfect paper, but found he had not the material to enable him to do so; he had therefore used what information he had, and had only referred to and analysed the statistics of the Colony during the period they had been taken, reserving further investigation on the subject:—

The science of moral statistics is one which every well-governed Country ought to cultivate, the most important branch of which is that which relates to the commission of crime; and it is one of those most easily susceptible of numerical computation. The nature of the act is generally sufficient to indicate the object aimed at. The sex, age, civil and social condition of the offender point out the principal circumstances which influence the method of the act. The degree of instruction he has received will to some extent indicate the degree of moral restraint to which he is subject, while the immediate motives, when not inferable from the visible circumstances of the case, will be found on investigation to be much fewer in number, more simple in character, and easier of classification than is generally supposed. Almost all crimes have upon investigation been referred by English Statisticians to one of four motives, viz.:—desire of gain, indulgence of sexual passions, malice, or wantonness. Having lately been led to an examination of our criminal statistics, I propose to lay the results of the investigation before the Society this evening. This, of course, is not the place in which the subject in its political bearing, as it is connected with the education controversy, should be discussed. It is in a philanthropical point of view that I approach its consideration in the light which the recorded facts of the last thirteen years throw upon the question in regard to the Country in which we live.

In the Statistical Register of New South Wales, from the year 1860 down to the year 1872, the last year for which the statistics are published, we have a complete record of the educational state of our criminal population, in so far as "reading and writing," "reading only," or "not reading at all," can be accepted as forming a test of education.

The tables are presented under two distinct heads—the one relating to offenders incarcerated in the gaols of the Colony, and for the most part dealt with by the superior Courts—the other confined to persons laid hold of by the police, and dealt with in the Police Courts summarily.

The forms in which the information is conveyed were prepared under my directions when I held the office of Registrar-General, upon the English model, to show the degree of instruction under these three heads, viz., those "who could read and write," those "who could read only," and those "who could neither read nor write."

I will first invite attention to the general results of the inquiry for the thirteen years from 1860 to 1872 inclusive. The total number of prisoners in the gaols of the Colony was 97,759. Of this number there could both—

Read and write	58,531	=	60	per cent.
Read only	14,698	=	15	,,
Not read	24,530	=	25	,,
	97,759	=	100	,,

that is to say, 75 per cent. had received more or less instruction, whilst 25 per cent. were totally ignorant or uninstructed.

Of the summary jurisdiction cases there were for the same period a total of 214,552. Of this number there could—

Read and write	123,497	=	58	per cent.
Read only	39,078	=	18	,,
Not read	51,977	=	24	,,
	214,552	=	100	,,

That is to say, 76 per cent. had received more or less instruction, whilst 24 per cent. were totally ignorant or uninstructed.

Now these results, it must be confessed, are unsatisfactory; they are calculated to create an unfavourable impression as to the moral restraints which instruction—to the extent of reading and writing at least—place upon the passions; and they militate against the generally received theory that ignorance is the mother of crime. But as I should prefer to put it, they show that in so far as mere reading and writing are admitted as tests of education, they entirely fail in repressing criminal propensities.

Now, in order to arrive at a just conclusion on this very important subject, it will be necessary to analyse the statistics more closely; but it is not my intention to trouble you with the tables of figures from which the results are obtained; they are quite at the service of the Society if the Council should see fit to print them as an appendix to the paper, so that any inquirer may verify the facts by the published returns from which they are taken.

In the first place, I would observe that in the discussion of the question as to the influence which education exerts in the repression of crime, one cannot help being forced to the conclusion that much misapprehension has arisen from confusion of terms—from treating mere instruction in the elementary arts of reading, writing, and arithmetic as education.

I may be excused, perhaps, if I say a few words on this matter. Instruction then in its broadest sense—as it appears to me—is merely the intellectual training by means of which the mind acquires the power of discerning and correctly appreciating things and persons, and the faculty of reasoning upon the things observed, while education may be said to consist of that moral combined with intellectual training by which the mind is taught to discern, and the heart is led to feel, the great object for which man is created, and the duties which in this stage of his existence he is called upon to fulfil.

But there is a narrower meaning more commonly ascribed to the term "instruction," whereby it is limited to an initiation in the arts of reading and writing. It is obvious that in this sense instruction is insufficient of itself to repress criminal passions, which are not the result of any action of the mind, but spring from the secret impulses of the heart. This is the high attribute of education, of which instruction is merely the handmaid—an instrument, as it were, to prepare the mind for the reception of the seed which education is to sow.

Instruction does not necessarily imply the inculcation of knowledge calculated to give a right direction to the energies of the mind—it may make a man learned, but not of necessity good—it may store the head with knowledge and brace the mind for great exertions, but may leave its possessor utterly ignorant of the nature or of the value of virtue.

For these reasons, it is a question how far the degree of instruction possessed by an individual may be taken as evidence of the amount of education which he has received. Applied to single cases it would certainly not hold good, for such instruction may have been imparted without any reference to the highest object of his existence, or without the recommendation of a single virtue, the acquisition of which is the proper end of all education; while on the other hand, moral discipline, the most precious fruit of education, may have been acquired by oral communication without any acquaintance with the ordinary instruments of knowledge.

If this reasoning is correct, it follows that we cannot reasonably look to secure immunity from crime by means of any form or degree of instruction, which is directed rather to the improvement of the mind than to the cultivation of the moral feelings of the heart; and in support of the accuracy of the reasoning, I think I may point to the facts to which I am about to invite your attention.

We will proceed then with the inquiry, and, before passing on to a closer examination of our own statistics, I would take leave to refer to those of the Mother Country, as they relate to the bearing of instruction on crime. In the volume of Miscellaneous Statistics of the United Kingdom of the year 1872 (the only one I have been able to lay my hands on) I find a table showing the degree of instruction of criminal prisoners in England and Wales for the three years 1868 to 1870, by which it appears that 65 per cent. belong to the classes which could read and write and had received a superior education, whilst 35 per cent. are put down to the ignorant or uninstructed classes. I am sorry that I cannot give the proportion which the uneducated class bears to the whole population. This information is very essential to the right apprehension of the question under consideration, but unfortunately it does not appear in the statistics to which I have had access. Our returns, as I before showed, give 75 per cent. as belonging to the instructed classes, and 25 per cent. to the uninstructed.

I will now proceed to analyze the gaol returns of New South Wales more minutely; and, firstly, I will draw attention to them as I find them classified into ages. Of the total number of prisoners received into the gaols of the Colony for the thirteen years under review there were as follows:—

Under the age of 20 years	8·	per cent.
From 20 to 30 years	30·	„
„ 30 to 40 „	26·	„
„ 40 to 50 „	19·	„
„ 50 upwards	17·	„
	100.	

Thus we see that, whilst the average of crime up to *twenty* years of age is represented by 8· in the 100·, the next twenty years (20 to 40) is represented by 56· in the 100·; whilst the remaining ages (from 40 upwards) yield 36· in the 100·. We will now look to the degree of instruction with which these people are credited. It is as follows, namely:—

	Under 20.	20 to 30.	30 to 40.	40 to 50.	50 and upwards.	
Read and write ...	53·	66·	61·	57·	49·	per cent.
Read only	15·	14·	17·	18·	17·	„
Cannot read	32·	20.	22·	25·	34·	„
	100·	100·	100·	100·	100·	„

It is somewhat remarkable to notice that the ages twenty to forty which, as we have seen, exhibited 56· per cent. of the crime, should also exhibit a proportionably higher degree of instruction; for whilst the average of all the other ages is represented by 53· in the 100, the average of the ages from twenty to forty reaches 63·50 in the 100—an excess of 10·50 per cent.

Now, I have no desire to press these results beyond their legitimate conclusion, but they do seem to me to expose the fallacy of the theory that the money spent on schools will, *as a necessary consequence*, be saved on gaols and lock-ups.

But there is a further test to which I should wish to subject these results, and without which the investigation would be obviously imperfect. That test is the educational state of the population at the respective ages, as it was ascertained by the Census of 1871. Well, then, I find that after casting out the children under five years of age it was as follows, namely:—

	Ages under 20.	20 to 30.	30 to 40.	40 to 50.	50 and upwards.
Read and write	61·	83·	76·	73·	66·
Read only	17·	7·	9·	11·	14·
Not read	21·	9·	14·	15·	19·
	99·	99·	99·	99·	99·

We see by these figures that a proportionably larger percentage of the ages twenty to forty had received a higher degree of instruction than had fallen to the lot of the ages above and below; for while 79· per cent. represents the average of the former, 66· per cent. represents the average of the latter. There is this further noticeable feature presenting itself on a comparison with the gaol returns—that whereas the mean of the uninstructed of the ages above specified was by the Census 16· per cent., the mean of the uninstructed in the gaols was 26· per cent.; whilst, on the other hand, the mean of those who had received more or less instruction was by the Census 83 per cent., and by the gaol returns 73· per cent.

But a fairer application of this test may perhaps be made by taking the figures which refer exclusively to the year 1871, the year of the Census; and suppose we cast out all the boys and girls under fifteen years of age—as rarely, if at all, coming within the criminal class—we arrive at the following results, and I should add that they are exclusive of the Chinese and aboriginal population, namely :—

Population, 285,010—			
Read and write	227,313 =	79·76	per cent.
Read only	27,541 =	9·67	„
Not read..........................	30,156 =	10·57	„
	285,010 =	100·00	„
Prisoners in gaol, 8,954—			
Read and write	4,698 =	52·47	per cent.
Read only	1,972 =	22·02	„
Not read..........................	2,284 =	25·50	„
	8,954 =	100·00	„
Summary jurisdiction, 18,025—			
Read and write	13,664 =	75·81	per cent.
Read only	1,259 =	6·98	„
Not read..........................	3,102 =	17·21	„
	18,025 =	100·00	„

We have here another picture presenting somewhat different features to those which have been exhibited before. We here see that of the ages from fifteen upwards there were by the Census a proportion of the population who had received more or less instruction reaching 89·43 per cent., and of the uninstructed 10·57 per cent. ; whilst of the prisoners in gaols it appears that the proportions were—of those more or less instructed 74·49 per cent. and of the uninstructed 25·51 per cent. And as regards the summary jurisdiction cases, the returns exhibit a proportion of those more or less instructed amounting to 82·79 per cent., and of the uninstructed 17·21 per cent.

Now, in surveying these figures, one cannot help being struck with the overwhelming proportion of the educated classes dealt with summarily in the Petty Session Courts, and the small proportion of the uneducated ; for when we reflect upon the habitual drunkards and vagrants who are laid hold of by the police, and appear again and again in the police lists, one might have expected the figures to have been reversed—it would not, at all events, have filled me with surprise to have found it so.

But to proceed with our inquiry and to satisfy the possible objection to the exclusion of so large a proportion of the youthful population as has been done in the foregoing calculation, I will take the figures of the Census from five years old and upwards, and compare them with the criminal returns The results are as follows :—

	Census. Per cent.	Gaols. Per cent.	Summary Jurisdiction. Per cent.
Read and write.........	70	52	76
Read only	13	22	7
Not read	17	26	17

It is singular to observe this close correspondence as regards the decree of instruction between the Census and Summary Jurisdiction returns—the proportion of those not able to read being the same in both cases.

I have not hitherto deemed it worth while to distinguish the sexes separately, but the returns for 1871 present such a singular discrepancy in the proportions as to make them worthy of notice. I will give the results as in the previous statement:—

	Census. Per cent.	Gaols. Per cent.	Summary Jurisdiction. Per cent.
Males:			
Read and write	71	62	78
Read only	11	17	6
Not read	18	21	16
Females:			
Read and write	70	29	69
Read only	15	34	10
Not read	15	37	21

I am unable to offer any suggestion that would afford a satisfactory explanation of the singular discrepancy in the figures which represent the relative proportions of the males and females—as regards their educational status—in the gaols of the Colony; and I do not care to pursue the inquiry further in this direction.

There are other points of view from which the criminal statistics to which I have adverted may be regarded. I have as yet made no comparison between the returns of the earlier and later period under review. I propose, therefore, before closing the present inquiry, to glance at them in this light; and in order to make a fair comparison, I will cast off the figures representing the earliest year of the thirteen, and divide the twelve years—1861 to 1872—into two equal parts, and compare the mean of the two periods in regard to their respective educational standards. I find then that of the prisoners received into the gaols of the Colony during the six years 1861 to 1866, and 1867 to 1872, there were respectively, who could

	1861 to 1866. Per cent.	1867 to 1872. Per cent.	Difference. Per cent.
Read and write	58	62	4 increase
Read only	12	18	6 ,,
Not read	30	20	10 decrease
	100	100	

Whilst of those offenders laid hold of by the police and dealt with summarily, there were respectively who could

	1861 to 1866. Per cent.	1867 to 1872. Per cent.	Difference. Per cent.
Read and write	46	73	27 increase
Read only	26	8	18 decrease
Not read	28	19	9 ,,
	100	100	

The results of these comparisons are singular, but I have no means of accounting for the difference exhibited in the educational proportions of the two periods.

The facts here brought under review are merely preliminary to a very wide field of inquiry which lies open before us, and invites investigation. There is the nature of the offence, the locality in which it is committed, and the number of times the offender has been punished before. Such inquiries as these in connection with the nationality, religion, age, sex, civil and social condition of the offender, require more time and labour than I have at command at present, and would occupy more time than would be convenient for discussion at one reading, and all this is in connection with our own statistics. Then there is the collection of materials for comparison with other Countries similarly situated with our own, which forms a third subject of inquiry not less interesting nor less important. When I have leisure I may pursue the inquiry further in these directions, but I should be glad if some other member of the Society would take up the question, who might be able to devote more time to its investigation than I can promise myself.

Some persons may, perhaps, inquire the practical utility of investigations of this kind—how a knowledge of the facts connected with crime will conduce to the main object in view, namely, its repression. The reply is, that a standard of comparison having been once obtained, we can ascertain how each locality in which we are interested differs from the average, and by examining the nature of the offences and the condition of the offenders, we may elicit the local causes which create an excess.

The value of statistical information on this important question cannot be doubted. It will stimulate the benevolence, and give aim and effect to the energies of the philanthropist; it will furnish the legislator with materials on which to found remedial measures for social derangement; and though the conclusions may consist in a bare numerical statement of aggregate results, yet they come home with all the power of stubborn facts, and often tell more than the most eloquent moral appeal. From information thus furnished, it cannot be questioned that public attention is often fastened with an intensity never before given to the subject, to the moral degradation of a State; and means have been adopted for carrying the blessings of education and order into those dark recesses where ignorance and vice appeared to have most strongly fortified themselves.

The individual who seeks facts merely to support a hypothesis in which he blindly believes will throw them aside the moment they militate against his arguments; but the man who seeks facts to discover the truth will abandon his hypothesis the moment those facts resist his efforts to reduce them into accordance with it.

Since writing the foregoing I have been favoured with a copy of the Criminal Statistics of New South Wales for the year 1873. In their general results they do not differ materially from those of the thirteen previous years,—that is to say as regards the offenders lodged in the gaols, for it seems that the "uninstructed" supply about *one fourth* of the whole.

The figures are—

	Persons.	Per cent.	Average 1860 to 72.	Difference.
Read and write	4,221	43·	60·	17 decrease.
Read only	3,103	32·	15·	17 increase.
Not read	2,367	24·	25·	1 decrease.
	9,691			

The difference here, it will be observed, is in the relative proportion of those who are credited with the higher and secondary degree of instruction ;—in the first case there is a decrease of 17 per cent., and in the second case an increase in exactly the same proportion.

The Summary Jurisdiction cases again exhibit different results. These are the figures :—

	Persons.	Per cent.	Average 1860 to 72.	Difference.
Read and write	17,016	78·	58·	20 increase.
Read only	1,173	5·	18·	13 decrease.
Not read..............	3,595	17·	24·	7 „
	21,784			

Thus we see that the offenders credited with the higher degree of instruction yield a proportion of 20 per cent. in excess of the average of the thirteen previous years, while there is a proportional decrease of 13 per cent. in the class which is credited with reading only, and of 7 per cent. in the uninstructed class.

I have also the Criminal Statistics of Victoria for the year 1873 before me, and perhaps a comparison with our own may present some points of interest. They are somewhat differently classified. They distinguish—

1st. Those unable to read.

2nd. Those who can read only, or can read and write imperfectly.

3rd. Those who can read and write well ; and, 4th, those who have had superior instruction, a class which has no place in our returns, and which contributes 285 only to the 43,403 forming the total of those who were taken into custody, summarily disposed of, or held to bail, or tried and convicted during the year. The figures are—

	Persons.		Per cent.
Read and write well	9,968	=	23·50
Superior instruction	285	=	00·67
Read only, or read and write imperfectly	23,960	=	56·50
Cannot read	8,190	=	19·33
	42,403		100·

Comparing these results with New South Wales, they come out as follows :—

	Victoria.	N.S.W.
Unable to read	19·33	17·
More or less instruction	80·00	83·
Superior ditto	00·67	00·
	100·	100·

I will detain you but one moment longer, to show the comparative proportion of criminals in the two Colonies to their respective populations, viz. :—

	Population.	Criminals.	Per cent.
Victoria	790,488	42,403	5·36
New South Wales	560,275	31,475	5·61

That is to say, the number of offenders in Victoria last year was as 536 in 10,000, and in New South Wales as 561 in 10,000, a difference of 25 in 10,000 in favour of Victoria.

I shall not, I feel satisfied, expose myself to the charge of advocating the cause of ignorance as opposed to instruction in the remarks which I have offered; I have only endeavoured, in so far as the inquiry has extended, to elicit the truth from the data with which I have to deal.

My own convictions, founded upon the facts I have endeavoured to illustrate, go to this extent only, that the assertion that "the illiterate person commits ten times the number of crimes that the educated one does" is not, in so far at least as New South Wales is concerned, borne out by facts, and it is no disparagement to the cause of education to say that you must not expect crime to decrease *in the same ratio* that schools increase.

DESCRIPTIONS OF ELEVEN NEW SPECIES OF TERRESTRIAL AND MARINE SHELLS FROM NORTH-EAST AUSTRALIA.

By John Brazier, C.M.Z.S., &c., &c.

[*Read before the Royal Society*, 23 *September*, 1874.]

These new species were collected by me when I went with the Australian Eclipse Expedition of December, 1871; and my continued absence from Sydney, in exotic Countries, collecting, has prevented me from describing them any sooner. The specific names attached are those of the leading Astronomers to the Expedition.

*1. Helix (Conulus) Elleryi.

Shell minutely umbilicated, conical, very thin, pale brown, finely regularly and spirally striated; spire conical, acute, suture impressed with a fine groove, whorls $5\frac{1}{2}$, slightly convex, the last whorl sharply keeled at the periphery; base convex, glossy round the umbilicus, about one half marked with spiral lines, peristome simple, slightly angular, aperture oblique, margins distant, columellar margin curved slightly over the umbilicus.

Diam. maj. $1\frac{1}{2}$, min. 1, alt. $1\frac{1}{2}$ lin.

Hab. Fitzroy Island, north-east coast of Australia; found under leaves in damp ground. (Coll. Brazier.)

I have named this species after Mr. Ellery, Government Astronomer of Melbourne, Victoria.

*2. Helix (Conulus) Russelli.

Shell minutely umbilicated, turbinately globose, thin, shining, faintly and obliquely closely striated; horny brown, spire elevated, apex obtuse, suture channelled, whorls 5, roundly convex, last descending in front, base convex, transversely striated, peristome simple, thin, roundly lunate, aperture oblique, columellar margin dilated partly over the umbilicus with white callus.

Diam. maj. $1\frac{3}{4}$., min. $1\frac{1}{2}$, alt. $1\frac{1}{4}$ lin.

Hab. Fitzroy Island, north-east coast of Australia, under leaves on damp ground; found also at No. 8 Island, Claremont Group, off Cape Sidmouth, amongst the drift coral above high-water mark. (Coll. Brazier.)

I have named this species after Mr. Russell, the Government Astronomer of Sydney, New South Wales.

*3. Pupa (Vertigo) Macdonnelli.

Shell small, dextral, umbilicately fissured, oblong, thin, shining, smooth, white, hyaline, whorls 5, rounded, the last small, suture impressed, narrow, apex obtuse, aperture somewhat squarely ovate, longer than broad, denticulated with 5 teeth, 4 prominent, the upper one large, placed on the centre of the aperture on the body whorl and extending upwards into the thick rounded callus on the face of the body whorl; a second placed to the right, minute and rounded; a third on the columellar, thick and pointed; a fourth facing the upper, moderately pointed; the fifth, about equal size to the fourth; the aperture divided into four parts, peristome thickened and expanded, smooth and white, margins joined by a thick callus continuous with the peristome, and extending over the body whorl.

Length 1, breadth ½ lin.

Hab. Fitzroy Island, north-east Australia; also, No. 8 Island, Claremont Group. (Coll. Brazier.)

I have named this after Mr. W. J. Macdonnell, Astronomer, of Sydney.

4. Pupa (Vertigo) Scotti.

Shell dextral, fissured, cylindrical, thin, transparent, pale brown, whorls 5½, roundly convex, last small, obliquely and transversely faintly striated; spire roundly obtuse, aperture small, ovate, denticulated, within with 4 prominent white teeth; one placed on the body whorl, elongated and rounded, second on the columellar, long and acute, two placed inside the outer lip, the lower one long and prominent, the fourth moderately long and rounded, peristome whitish, thickened and expanded, margins continuous, with a thin coating of callus over the perforation, suture formed at the upper part of the lip.

Length ¾, breadth ½ lin.

Hab. Fitzroy Island, north-east coast of Australia; only one specimen obtained at the watering-place, under a bit of wood. (Coll. Brazier.)

I have named this after the Rev. W. Scott, Astronomer, Sydney.

*5. Cyclophorus (Ditropis) Whitei.

Shell suborbicular, somewhat depressed, rather thin, obliquely rugosely striated, spine scarcely elevated, apex obtuse, smooth, whorls 4½, increasing rapidly, last large, flattened, spirally keeled with one above and below the periphery, having a hollow appearance, suture distinctly keeled, umbilicus large, one prominent keel round it, aperture oblique, circular, peristome simple, thin, acute, operculum horny yellow, thin, concave, multispiral.

Diam. maj. 1, min. $\frac{3}{4}$, alt. $\frac{3}{4}$ lin.

Hab. Fitzroy Island, north-east coast of Australia; found under wood near a fresh-water stream. (Coll. Brazier.)

This interesting species belongs to the new sub-genus *Ditropis* of Blanford's; it reminds one of a miniature *Tropidophora cuvieriana* and *tricarinatus*, with their large keels. I have named it after Mr. White, F.R.A.S., Astronomer of Melbourne, Victoria, he having accompanied me across the Fitzroy Island.

*6. Diplommatina Gowllandi.

Shell dextral, rimate, acuminately oblong, finely and obliquely ribbed, interstices smooth, white, hyaline, spire conical, apex acute, sometimes decollated, whorls from 6 to 7, sometimes 9; the first three forming the apex are regular and tapering, the fourth broad, the fifth longer and broader, sixth very small, having a pinched or distorted appearance in front; seventh or last extends nearly up to the suture of the sixth; convex, aperture vertical, sub-circular, peristome thin and broad, margins shining, joined by a thin callus, upper broadly expanded, columellar margin thick, straight, with a small canal, minute tooth within.

Length $1\frac{1}{2}$, breadth $\frac{3}{4}$, min. $\frac{1}{2}$ lin.

Hab. Fitzroy Island, north-east coast of Australia; found at the root of a large tree, crawling upon the grass and roots during a heavy rain. (Coll. Brazier.)

This curious species differs from any of the *Diplommatina* that I have met with; the first three whorls forming the apex are regular and tapering, the fourth is a little broader, the fifth still longer and broader, the sixth having a pinched-in appearance; the last is large, giving the shell a most distorted appearance. The greatest breadth is at the fifth whorl, the least at the sixth. The few hundred that I collected are all of the same description, very few with nine whorls.

I have named it after my late lamented friend John Thomas Ewing Gowlland, Staff Commander, R.N., who was unfortunately drowned while employed surveying Port Jackson, August, 1874, and the gentleman who took charge of the steamer of the Eclipse Expedition to Cape Sidmouth. The many pleasant hours spent with him will always be remembered by the members of the Australian Eclipse Expedition.

* 7. Chondrella multilirata.

Shell imperforate, globosely conical, strongly spirally lined, interstices rather rough, shining, reddish-brown, whorls 4, roundly convex, suture cancelled, spire conical, apex papillose, base convex, very finely marked with spiral lines, aperture vertical, lunate, peristome thickened, margins distant, columella margin straight, thickened with a white callus round the imperforation which is hollowed out, operculum shelly, ovate, smooth, brownish, with a long pointed shelly protuberance on the under side or place of attachment to the animal.

Diam. maj. $\frac{3}{4}$, min. $\frac{1}{2}$, alt. 1 lin.

Hab. Fitzroy Island, north-east coast of Australia; found crawling on the roots of grass, in company with *Diplommatina gowllandi*. (Coll. Brazier.)

This interesting microscopic species I place it in the Genus *Chondrella* of Pease. Not having seen the description of that Genus, only having specimens of Pease's *parva* from Rorotonga, one of the central Pacific Islands, which I find comes very close, both in the shell and operculum, to my Australian species, of which I collected some hundreds, I am of opinion that Chondrella is only a synonyme of the Genus Garrettia, O. Semper.

8. Columbella (Mitrella) Russelli.

Shell cylindrically oblong, somewhat fusiform, smooth, white, whorls 6, moderately convex, encircled with oblique dark orange spots on the last whorl, first row large, below long and reticulated, above the suture arrow-shaped, aperture oblong, ovate, peristome thinnish, irregularly curved, thickened at the upper part with callus, columellar marked with fine grooves, canal short, straight.

Length $2\frac{1}{4}$, breadth $1\frac{1}{4}$ lin.

Hab. No. 6 or Eclipse Island, Claremont Group, north-east coast of Australia. I only found one specimen under a stone during our stay of nine days. (Coll. Brazier.)

9. Columbella (Anachis) Digglesi.

Shell oblong ovate, thin, glassy, whitish, marked with oblique reddish lines running from left to right, longitudinally finely ribbed, rounded, whorls $5\frac{1}{2}$, tabled at the suture, apex acute, light blue, aperture ear-shaped, half the length of the shell, outer lip minutely denticulated within, columellar curved, finely striated, callus extending up to the upper part of the lip, canal short.

Length $1\frac{1}{2}$, breadth $\frac{3}{4}$ lin.

Hab. Fitzroy Island, north-east coast of Australia. (Coll. Brazier.)

This fine species I obtained at a depth of 18 fathoms, brought up on a piece of Retepora taken off a rocky bottom. I have named it after Mr. Silvester Diggles, author of a work on Australian Ornithology, and one of the observing party of the Eclipse Expedition from Queensland.

* 10. Columbella (Anachis) Gowllandi.

Shell oblong ovate, rather thickened, horn yellow, longitudinally ribbed as far as the centre of the last whorl; below obliquely striated, ribs rounded and smooth, interstices smooth, whorls 8, moderately convex, encircled with a reddish band on the centre of the whorls; on the last two bands appear, one on the centre and one below, grained at the suture, interstices smooth, apex acute, very smooth, aperture ear-shaped, short, outer lip thickened, smooth, columellar curved, coated with callus, upper part with a denticulation of callus spreading out towards the outer lip, lower part strongly obliquely ridged, canal short straight.

Length 2¼, breadth 1 lin.

Hab. No. 6 or Eclipse Island, Claremont Group, north-east coast of Australia, under stones. (Coll. Brazier.)

Of this species I obtained three specimens at the above locality, and when visiting the Solomon Islands in 1872 in H.M.S. "Blanche," I collected four specimens at Makera Harbour, San Christoval. It comes near to *Columbella atrata*, Gould, *C. lentiginosa*, Hinds, two Port Jackson species, and *C. troglodytes* and *regulus*, Souverbie, from New Caledonia.

* 11. Liotia Gowllandi.

Shell solid, depressedly orbicular, white, obliquely rugose, interstices smooth, whorls 5, the last very large, grooved spirally at the periphery, and above and below it, giving the shell the appearance of three granulated spiral ribs, suture depressed, smooth, apex acute, smooth, base rounded, ribbed, umbilicus moderately large, encircled by a spiral rib, aperture oblique, circular, lip continuous, white, thickened.

Diam. maj. 1¼, min. 1, alt. ¾ lin.

Hab. Percy Island No. 2, north-east coast of Australia; found under stones. (Coll. Brazier.)

This charming species approaches near to *Liotia speciosa*, Angas, from Port Jackson. I obtained six specimens during a stay of two hours only at the Percy Island.

The species marked with an asterisk I have deposited in the British Museum.

IRON PYRITES.

By J. Latta, Esq.

[*Read before the Royal Society*, 14*th October*, 1874.]

Mr. Thompson read the following paper on the treatment of iron pyrites by Mr. J. Latta, who was unavoidably precluded from being present.

Mr. President and Gentlemen,—At the request of some of the members of the Royal Society, I have ventured to occupy part of your time this evening in describing the method of treating pyrites for the extraction of its gold, as carried out by the Port Phillip Company at Clunes.

In 1861 I was engaged by that Company as their chemist and assayer, with special instructions to devise, if possible, a process for profitably extracting the gold from their pyrites, which was then but little better than a waste product. Except processes inapplicable to our circumstances, such as smelting, &c., the only known means for extracting gold from such mineral was that practised in South America and the United States—" of exposing the auriferous sulphides to the action of air and moisture for a year or so, whereby a portion of the mineral became oxidised, liberating the gold previously enclosed by the sulphides, the mineral was then passed through the stamping battery with quartz, and whatever portion of the sulphides remained undecomposed was retained, as well as the then rude machinery for that purpose admitted, to undergo another term of oxidation, and so on whilst any remained." I scarcely need to point out how extravagantly wasteful of time and gold such a process must have been. Yet even at the present time this process is occasionally practised in Victoria. At some claims the blanketings—that is the pyritous sand, with a little free gold caught upon the blankets—are, after a time, again put through the batteries with the quartz, for the purpose of extracting its gold. Any one practically acquainted with the treatment of mineral containing fine gold by the battery process, will at once recognise the impossibility of retaining a fair proportion of such minutely divided gold as oxidised pyrites affords; by far the larger portion would be held in suspension by the water, and be carried away by it through all the appliances devised for its retention. In addition to the difficulty of retention arising from the fine state of division which gold so obtained possesses, most of these particles would be coated with iron oxide, and other products of the decomposed mineral, thus offering another hindrance to its chance of amalgamating with the mercury. This latter difficulty deserves careful consideration, where fine gold has to be dealt with, as from its fineness it escapes the scrubbing which the larger grains receive from contact with the quartz whilst crushing, whereby their surfaces are cleaned, and thus rendered extremely sensitive to the influence of mercury placed for their detention. In reference to the condition of gold in pyrites, it has come to be pretty generally admitted that "nearly, if not quite all, the gold exists in the metallic state." This quite agrees with the results of some experiments carried out by myself in conjunction with Mr. Daintree, late of the Victorian geological staff. Our researches ended in obtaining but the barest possible evidence of gold existing in a mineralized state in pyrites. As a matter bearing somewhat in support of this result, and whilst engaged in these investigations, I had the good fortune to come across some fine specimens of cubical pyrites, which upon examination with a pocket lens, seemed to indicate the presence of gold; upon transferring them to a good microscope gold was distinctly seen upon the planes of cleavage, and upon dissecting the crystals, every cleavage was found distinctly gilded. Now, from the fact that the presence of gold could only be determined by the aid of a good microscope, and that only as a fine gilding, some notion may be formed of the excessively fine state of its division, and how unsatisfactory would be the task of separating such liberated films from water in motion.

Guided by these considerations, it became evident that any attempt to mechanically separate gold from pyrites—unless aided by the previous decomposition of its enveloping sulphides—must prove ineffective from the impossibility of reducing it to its ultimate atoms, for so long as a cluster of sulphide atoms remain unbroken, they might reasonably be imagined to enclose those of gold. Again, it was equally clear that, when such gold *was* liberated from its envelope, water concentration alone was inapplicable. To test the correctness of these conclusions, each of them was made the subject of rigid experiment on an extended scale, before receiving them as fundamental truths to guide us in determining the best method suitable to our requirements. Two parcels of pyrites, of twenty tons each—one roasted, the other unroasted—were ground in one of the best arrastras known, with mercury; a constant stream of water flowing through to carry off the finely-ground sand, which was then carried through mercury boxes and over blankets. Each parcel received the same amount of grinding and treatment in every detail. The results are as follows:—

20 tons raw sand, containing 3 oz. 6 dwts. per ton.		20 tons of roasted sand, 1 oz. 7 dwts. 10 grs. of gold per ton.	
Gold obtained	29·21 p. c.	Gold obtained	51·57 p. c.
„ in tailings	42·84 „	„ in tailings	27·21 „
„ carried off in water	27·95 „	„ carried off by water	21·22 „

Here it will be observed that, with the raw sand, only a small proportion of the gold was obtained—a very much larger was left in the tailings, although finely ground; and a large proportion was carried off with the water as slime. With the *roasted* mineral more than half the gold was obtained; the tailings were much poorer than those from the raw sand, but still very rich, and a large quantity was carried off by the water.

After carefully considering the merits of the various methods suggested for extracting gold from pyrites, it was determined to attempt it by a mechanical process. Profiting by our acquired knowledge of the condition of gold in pyrites, our first problem to solve was how to best destroy the enveloping sulphides and arsenides, so as to get rid of the deleterious action of those minerals upon the mercury used for amalgamating and detaining the liberated gold; and, secondly, the best method of extracting the gold from the decomposed pyrites. After a number of experiments on a large scale, it was decided to effect the decomposition of the pyrites by a roasting process. To effect this economically, I devised, and in conjunction with Mr. H. A. Thompson patented, in 1862, the Inclined Roasting Furnace, which is now used in many places throughout the Colonies. It consists of an inclined roasting hearth, usually about 30 feet long by 5 feet wide; the fire-hole for heating the hearth crosses the lower end of it, and is separated from it by the fire-bridge; between the latter and the hearth is a channel for carrying into the store-pit the sand when roasted. In the foot wall of the furnace are six tubes, from 1½ to 2 inches diameter, for supplying heated air to the roasting sulphides; scarcely any air is admitted through the fire-bars, the gaseous vapours from the fuel being completely burned by the great excess of air passing over the fire for oxidising the pyrites. Along each side of the furnace are five working doors, for the workmen to turn and rake down the mineral. Above the upper end of the furnace a large hopper is constructed capable of holding twenty-four hours' supply of sand; in the floor of this hopper is a trap for supplying mineral to the hearth; the hopper is filled by trucks, communicating with the buddles by a tramway to the stamp-house. The whole of the furnace is carefully braced with vertical, longitudinal, and transverse ties. The present furnace has been working about ten years, and, with fair treatment, will last many years more. In working this furnace the whole of the hearth is covered with pyrites to a depth of between two and three inches, kept at a gentle red heat, with frequent stirring, until the mineral nearest the fire, and about six feet beyond it, is found no longer to give off sulphur fumes. An experienced workman can determine when this condition has been attained by it appearance in the furnace. It is then raked into the discharge-channel, and the mineral lying upon the hearth immediately above that removed is brought into its place; again, that still further up is brought a stage lower, until the whole has been shifted, when the vacant place at the upper part is refilled from the hopper. The sulphurous and arsenical vapours, together with the products of combustion and dust from the pyrites, pass into a tunnel between 200 and 300 feet long, 4 feet high, and 3 feet wide, carried up the side of a hill, terminating in a chimney 30 feet high. Nearly all the sand and dust carried over by the draught is deposited within 40 feet of the furnace, and is periodically removed for retreatment, as it contains a notable quantity of gold; beyond 40 feet the sand is worthless. From the size of the tunnel the vapours move slowly onwards, and have, consequently, time to deposit any heavy particles; continuing their course, the vapours pass through six cellular brick screens, down which a powerful spray of water passes; here they get cooled and scrubbed, the sulphurous and sulphuric acids dissolved out, whilst the arsenious acid is deposited on the floor of the tunnel, scarcely anything escaping from the chimney but the fuel vapours. Some alarm was felt by the Town Council lest any arsenical vapours should escape and prove injurious to the inhabitants, as the works were close upon the township, and they placed the matter in the hands of Mr. Johnson, the Government analytical chemist, for investigation, who reported as follows:—"I drew five gallons of the vapours from the chimney of the roasting furnace, and by the application of one of the most delicate tests known to science, viz., Reinck's test, discovered but the merest trace of arsenic." I may remark that when this investigation took place we were condensing over two tons of arsenic per month in the tunnel. I have dwelt somewhat lengthily upon this part of my subject, as I am desirous to show that with due precautions such operations can be safely carried on in the neighbourhood of habitations.

In carrying out the roasting operations the work is divided into three shifts of eight hours each, one man being able to attend a furnace; his business being to keep up the fire, charge and discharge the furnace, and finally to cover up the hot sand discharged with damp sand and spray it with water. This quenching was found to be a matter of some importance, as the quartz sand—always found with the pyrites— is thereby broken up and rendered friable, by which the after-process of grinding is greatly facilitated. The quantity of sand which a furnace of the above-mentioned size can treat will average 4 tons per twenty-four hours, with a consumption of 3–10ths of a cord of wood per ton.

Having determined upon a mechanical process for extracting the gold from the roasted mineral, it became necessary to discover the best condition for accomplishing it. In this also we were greatly assisted by the knowledge gained of the physical condition of the gold in pyrites. Consequently, after our earlier experiments, already mentioned, we carefully avoided a current of water and ground with mercury without an overflow until it was considered the gold had become amalgamated. By cautiously varying the experiments, and ascertaining the proportion of gold obtained in each case, we were led up to the present method of working. From the results of a great number of experiments, it was shown that the quantity of water used in the grinding process was a matter of considerable importance, the success of the operation to a great extent depending upon the sand being in a damp condition only; by this means the mercury becomes thoroughly diffused, and every grain of sand has a particle of mercury in contact with it, consequently there is afforded abundant opportunity for the gold to amalgamate. On the other hand, if sufficient water has been used to convert the mass into a semi-fluid state, the mercury remained at the bottom of the mill, the surface only being in contact with the sand, consequently the opportunity for amalgamation was considerably lessened, and the quantity of gold extracted very much less than when working damp sand only. As the result of these experiments, the following process has been adopted:—The sand, after being roasted, is ground—only moderately damp—with an equal weight of mercury for three-quarters of an hour, under the rollers of a heavy Chilian mill; water is then allowed to flow into the basin, the mill still revolving, until nearly all the finely ground sand has been carried off in the overflow to the concentrator; the mill is then stopped, the water drained off from the unground sand and mercury, again started, and recharged with fresh sand, and so on until it is necessary to clear out the amalgam—generally once a week, depending upon the richness of the mineral treated. The finely ground sand passed into the concentrator is kept slowly stirred for a quarter of an hour, to keep the sand in suspension in the water, and allow the mercury and any amalgam which might have been carried over from the mill to gravitate through it; the water with its sand is then slowly run through a smaller concentrator, to retain any valuable particles which might have escaped the first, and is then considered sufficiently impoverished to be allowed to run away. The quantity of roasted mineral the Company treat by this process, when working, averages 18 tons per week—the duty of two mills worked in eight-hour shifts, one man attending them, alternately charging and discharging.

The average proportion of gold extracted during last year, from 294 tons of pyrites, amounted to 95·19 per cent. of the assays, the sand averaging $4\frac{1}{2}$ oz. of gold per ton. Some of the parcels returned as high as 98 per cent. during that period. The cost of extraction amounted to £2 2s. 4d. per ton, without estimating wear and interest on capital. The above charge is rather high, as fuel during that period was unusually dear, and the furnace being but 4 feet wide instead of 5 feet, increased the labour cost, as less work is done at the same cost than would be incurred in working a larger furnace. Another element in the cost is the mercury which is lost, amounting to 1 lb. 13 oz. per ton—a large proportion of which, I think, might be saved by improved appliances for that purpose, together with the gold contained in it. The immediate cause of this loss of mercury is the severe trituration to which it is subjected with the sand. This was found indispensable, for whenever, through oversight or experiment, a less degree of trituration was applied than that now used, or the sand ground too wet, the return of gold was invariably diminished by several per cent.

In carrying out these operations, I found that a *large* proportion of galena in the mineral seriously interfered with the extraction of the gold, but a *small* proportion of the sulphides of copper, zinc, or lead, produced no appreciable effect.

Taking the process as it stands, we have been unable to find one that would at less cost extract the same proportion of gold, or could be safely trusted in unskilled hands with only occasional supervision.

Mr. Thompson also read the following return:—

Returns of Pyrites treated at the Port Phillip Company's Works, Clunes, since October, 1866:—

Minerals treated: 1867, 215 tons 17 cwt.; 1868, 366 tons 9 cwt.; 1869, 401 tons 11 cwt.; 1870, 431 tons 9 cwt.; 1871, 561 tons 2 cwt.; 1872, 368 tons 6 cwt.; 1873, 294 tons.

Gold, contents per ton, per assay: 1867, 4 oz. 16 dwts. 6·93 grs.; 1868, 3 oz. 18 dwts. 6·56 grs.; 1869, 4 oz. 1 dwt. 19·15 grs.; 1870, 3 oz. 11 dwts. 4·34 grs.; 1871, 4 oz. 7 dwts. 10·99 grs.; 1872, 5 oz. 18 dwts. 19·36 grs.; 1873, 4 oz. 10 dwts. 16·30 grs.

Total Gold obtained: 1867, 960 oz. 13 dwts.; 1868, 1,322 oz. 13 dwts.; 1869, 1,515 oz. 11 dwts.; 1870, 1,370 oz. 4 dwts.; 1871, 2,290 oz. 1 dwt.; 1872, 2,061 oz. 9 dwts.; 1873, 1,268 oz. 17 dwts. 12 grs.

Gold extracted, per ton: 1867, 4 oz. 9 dwts.; 1868, 3 oz. 12 dwts. 4 grs.: 1869, 3 oz. 15 dwts. 11·60 grs.; 1870, 3 oz. 3 dwts. 12·60 grs.; 1871, 4 oz. 1 dwt. 15·20 grs.; 1872, 5 oz. 11 dwts. 22·56 grs.; 1873, 4 oz. 6 dwts. 7·63 grs.

Percentage of Gold extracted: 1867, 92·43; 1868, 91·71; 1869, 92·28; 1870, 89·24; 1871, 93·34; 1872, 94·22; 1873, 95·19.

SYDNEY WATER SUPPLY BY GRAVITATION.

By James Manning, Esq.

[*Read before the Royal Society, 9 December*, 1874.]

In coming before this Society with a paper having the above designation, I beg to say that the origination of this subject occurred when I was engaged twelve months ago with the railway engineer, Mr. Stephens, in making a reconnaissance survey of the Port Hacking valley and rivulet for a railway route to the southern coal mines and to Illawarra. On passing up the higher parts of that rivulet I was struck with the natural facilities which presented themselves in the neighbourhood of Bulgo to avail of the great geological north-westerly dip of the country, for the benefit of a water supply for Sydney by gravitation. I perceived that the waters of this rivulet could be supplemented with extra waters from the western slopes of the south coast and coal range, by reason of the great facilities that would be afforded by the northerly dip of 40 to 41 feet to the mile, and by the westerly dip of 60 feet to the mile along the whole of the coast range south of Bulgo and Coalcliff for twenty miles and more.

By the natural facilities produced through such gradients I foresaw that it would be a simple matter to divert all the upper waters of the great south coast range from their present courses down the Cataract and the Cordeaux Rivers into the Nepean, and to bring them all out north, towards Sydney, by an open aqueduct to the head of the Loddon River, and on through the obstructing cross range by means of a tunnel of no formidable nature, and to lead them, if required, into the Port Hacking River, which runs north throughout its main course.

The barometrical elevations of the countries all along and about the south coast range, behind Stanwell Park, Bulli, Wonona, Mount Kiera, and Mount Kembla, were known to me through the valuable researches in 1845, 1846, &c., of the Rev. W. B. Clarke, our venerated V.-President, and partly also through my own aneroid measurements on the south and east side of Madden's Plains, which I made during each of my two journeys there when in quest of the Illawarra Railroad. By these I made reasonable deductions of what could be done by canalling and tunnelling. The more I dwelt upon the subject the more firmly was I convinced of the soundness of my theory and premises, and I felt that it only required a survey of those parts to establish my assertions and belief in the availability of the whole of that country to bring about a grand water supply for Sydney by gravitation.

Such being my first thoughts of obtaining a rich supply of water by a very short cut, I determined to be reticent on the point until the regular survey of the Illawarra Railway should have progressed far enough to satisfy me that it must be an approved success. I waited for the issue for six months after the survey had commenced. My reason for this was that the establishment of the Illawarra Railway would be almost indispensable to my water supply scheme, not only by reason of the means it would afford of bringing up heavy pipes and large supplies of Portland cement and other materials for the water-works, but also by reason of the bridges that would necessarily cross George's River and Cook's River, and which would become the immediate means of conducting the water mains over those broad rivers on their course to Sydney.

All practical difficulties in the development of the Illawarra Railway line being apparently at an end, and being so firmly convinced that it would be adopted, by reason of its own immensely intrinsic value to the Colony, I resolved at once, and in May last, to register my thoughts for the gravitation water supply, by writing an official letter to the Colonial Secretary, in which I set forth my project in the form I expected it would so assuredly result in, after I should have made a survey of the adjacent country. The season of the year being then too inclement for a survey in the exposed region of Madden's Plains, I resolved to wait for the spring months before I made the attempt. Accordingly I started in October with a fully equipped party. I was kindly assisted by the Deputy Surveyor General with all requisite instruments for my survey. I formed my own party, and engaged the services of an experienced surveyor to assist me in the important work.

I made the starting point for my survey at that spot on the Bottleforest Road, near Bulgo, where the head waters of the Port Hacking rivulet take their rise, and which position I made by aneroid measurement to be 1,050 feet over the sea, and distant about 28 miles from Sydney. Here we drove our first starting-peg or "bench mark," and carried on the survey of traversing and levelling with the proper instruments. My course of starting maintained a dead level, nearly south, over an easy but scrubby country for two miles. At that distance we touched on the side of the upper part of the Woronora Creek, which was running with a fair stream. Here we were interrupted in our level course by the obstruction of the rising hill of the Bulgo, or Madden's Plain plateau, which forms the barrier between the

George's River on the north and the Loddon and the Cataract Rivers on the south. We continued our course nearly south for some 60 chains, in which short distance we proved (for my purposes) the favourable elevation of 220 feet 6 inches, to the intersection of the road that leads from the Bottleforest Road over Madden's Plains to Rice's free selection, which runs from east to west. We then traversed that road west to its junction with Madden's Creek, and continued the survey along the creek by its nearly due west course for a mile and a half from where we intersected the road to where this upper and main source of George's River is precipitated over a deep fall of 55 feet perpendicular. In this short distance the levels proved the fact of the advantageous fall of no less than 150 feet 9 inches.

This sudden rise to the south and sudden dip to the west seemed to me to be at once a convincing proof of the correctness of my preconceived theory, that it must become a very easy matter to lead a large source of water supply to the northward by means of a tunnel that should pierce the high land between the deflections on the south-west of Madden's Plains and the level on the north-west, and from as far back to the south as would be practicable with the required gradients for the full velocity of waters to be conducted through such tunnel. To this end I knew that the south and permanent affluents of Madden's Plains must be close at hand, where they unite into a respectable stream to form the upper source of the Loddon and Cataract Rivers. The survey was continued to those parts, and it immediately opened out the grandest results. We came upon the various small affluents of the Loddon River, where they unite at a spot that seemed to be formed for the express use of man to intercept the waters by one easily constructed dam of 46 feet high, that would throw back in times of freshes a lake of water equal to from 1,200 to 1,400 acres, of an average depth exceeding 22 feet. This supposed large acreage of water was arrived at by the aneroid and not by the levelling instruments, for reasons I will explain later; but I may here say that I believe that I rather under-state than over-rate the size of this one magnificent basin, which could be made at a comparatively small expense by means of a dam in concrete, at a most favourable spot, defined and marked out by myself. But not only can this immense reservoir be obtained at this grand spot, but there are positions above the back of this one intended dam, applicable for raising other embankments on the south side of Madden's Plains, which would give a total of several hundred acres more water. The country where these reservoirs would be is nearly free from timber, and is wholly constituted of barren sandstone, covered with coreas, water weeds, epacridæ, and such-like scrubby low-growing plants, whilst in the various creeks I perceived the evidence of perpetual streams in the presence of familiar water plants. This country is unfit for any purpose for man or beast, and is suitable only for its own special and high value as a great gathering ground for supply waters. It is there seemingly and essentially as the great water-sponge and filter whereby Sydney might be supplied to a very large extent in all seasons. My proposed dam being made, the storage of water within such one dam alone would be so enormous that it would hold enough water probably to supply Sydney with its present population for more than a whole year. It would be quite as large, if not larger, than the Prospect dam that was proposed to be made in connection with the Upper Nepean scheme; and as, by my proposed plan, the whole of the water could be drawn out from under the bottom of the dam for transmission below it into the Loddon tunnel, so it would represent the same depth of storage water available for Sydney as the Prospect dam, the upper 25 feet of which would only have been available for gravitation, as admitted. The supply in all seasons off the Madden's Plains swamps would be more than enough to keep pace with the evaporation from that reservoir, even if I had no other proposed and available source of supply to keep it up and overflowing.

The elevation of the lowest spot of this proposed lake would be at the level of the bottom of the dam, and that would be sufficiently high to admit of the whole of its waters being drawn off and conducted by a tunnel of 3 miles and 35 chains, to come out north, at the head source of the Port Hacking River, whilst such flowing waters would have a fall of 4½ feet to the mile all the way for seven miles to the intake of my proposed gravitation mains for Sydney direct, from 1,050 feet elevation.

Besides this large storage of water by this one dam and by its available tributary dams on the south side of Madden's Plains, I found that I could secure between 800 and 900 acres more water on the north side of same plains and on the ever running Madden Creek. This could be most easily and economically effected by the formation of three small dams at suitable sites: the first to be 9 chains wide and 25 feet high, which would give 400 acres of water; the second to be 7 chains wide and 15 feet high, to yield 230 acres of water, and the third to be 9 chains wide and 15 feet high, to give 200 acres of water; in all here 830 acres of extra storeage. All the fine and permanently running water of this creek, together with its own storage waters, could be lowered by means of a sluice into the Loddon tunnel through a shaft of 73 feet—such shaft to be cut out of the solid sandstone; and then all these cumulative waters of the Loddon and of the Madden River streams would pass on north-easterly by the tunnel, and on afterwards by the open canal of nearly 4 miles on to the intake at the mains, such waters being further supplemented on their way thither by the head sources of the Waranora River.

Thus I show means of obtaining storage ground equal to more than 2,000 acres, with power of still further supplementing such storage very considerably and to an almost unlimited extent from the grand upper slopes behind Bulli, Wonona, Mt. Kiera, and even Mt. Kembla, and for more than 20 miles southwards if required; all which supplies can be made to enter the proposed artificial lake at the Loddon swamps. All these waters, even from the furthest point south and at the inlet of the Loddon tunnel, would be within seven (7) miles of the intake of the high delivery mains. I believe that with such splendid catchment grounds, which would ever be supplied by nine (9) constantly running streams and by the frequent freshes, that we should secure water enough from thence alone for the full supply of Sydney in all seasons. But by the sequel it will be shown that the above-named supplies are not more than one half, or perhaps more than a quarter of the waters that I propose to secure for leading into Sydney when required.

At this stage of my paper, I deem it to be desirable to state that, having been over forty years uninterruptedly a resident in this Colony, I have witnessed the most frightful droughts, some of nearly three years duration; I have repeatedly seen the Nepean River, at the Cow-pasture or Camden River bridge, nearly dry. I have seen hundreds of water-carts in Sydney, filled at the Ultimo estate waters of former days, at the cost of 3d. per bucket prime cost; and during the great drought of 1839 I crossed the usually fine Murrumbidgee River dry-footed, at the ford above its junction with the Tumut River; therefore, I hope I may be trusted for not advancing any measure for a water supply for Sydney that should not be safely ready to meet the worst of such contingencies under such parallel circumstances which may at any time recur.

With such long experience before my mind, I cannot, therefore, be satisfied with the running waters and immense storage supplies of the before-named sources at the head of the Loddon, the head of George's River, and the head of the Waranora Rivers; we must have far more. In ordinary seasons we should be able to deliver not less than about 3,000,000 gallons daily into Sydney, from the head sources of Port Hacking River alone, and this supply can practically be supplemented to almost any extent by the surplus and over-flow waters which might be made to pass the high delivery mains. The total amount from this united source need not be less than 6,000,000 gallons daily. In order to effect the above-mentioned increase of supply from the more southern outlying country, I propose that we should avail ourselves still further of the grand north-westerly dip of the long coast range to the south and south-east of the Loddon Swamps. As the advantageous dip of 40 to 41 feet to the mile from south to north gives us a complete command of draining the upper parts of the western slopes of that range, therefore we should adopt this *gift of Nature* to our own uses, and cut a deep and narrow aqueduct through the sandstone country along such range, by such gradients as may be deemed to be most compatible for quick delivery, and to cut such canal as far as may be expedient for the additional requirements. That aqueduct would intercept all the head waters of the Cataract River, and further on, in times to come, and by the aid of a comparatively short tunnel, all the head waters of the Cordeaux could also be led through the Loddon tunnel, and onwards by high and low delivery mains into Sydney.

In my proposal to cut the aqueduct deep and narrow, I wish it to be understood that my object in this is to intersect as much of the north-westerly stratifications of the range as possible, so as to open out as many fissures of the sandstone formation as may be made available to give off into the aqueduct a large supply of pure water. To this supply too would be added all that we should obtain into such aqueduct from the swamps and tributary streams of the Cataract River that would be coming down the high range from above the level of the aqueduct, and which aqueduct we should throughout its course so contrive to keep up high enough to keep it clear of the broken gullies and deeply furrowed watercourses.

Besides the above additional resources for water, I would propose to make dams along the topside of this aqueduct, wherever the features of the country about the swamps and sources of streams admitted favourably of such action. All such supplementary dams could be lowered by their respective sluices into the canal, whenever there might seem to be any occasion for their adoption to keep the one great Loddon reservoir constantly full and overflowing; and thereby reduce the surface evaporation in dry seasons as much as possible.*

By such measures for the upper water supplies, I think I show, here alone, ways and means of providing the purest of waters in excessive quantities for all seasons, for a future population in Sydney that may number more than 1,000,000 people. But again, and in addition to all the above-named sources, comprising constantly running streams, and storage supplies of probably some 3,000 acres of deep water, averaging about 15 feet from its mean depth, I propose to have another immense storage supply in the Port Hacking River itself, by means of having another large concrete dam, to be erected at a well-suited spot on the river where the level of the waters is 149 feet above high-water spring tides, and where the features of the country

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* See note at page 56.

present extraordinary advantages for forming a fine dam across a very narrow gorge in this mountain valley, and where there is such an extent of level ground up the river that a proposed dam of 35 feet in solid concrete would render the most effective service, in throwing back an extraordinary amount of further storage waters, which, together with the upper waters, would bid defiance to all exhaustion from every cause. By my proposed water supply scheme, I do not pretend to supply waters for irrigation, beyond supplying gardens abundantly. In my opinion, no system of irrigation can be safely depended upon, unless where canals can be fed from large rivers or proximate mountain streams, which are more or less fed by melting snows, and where iron mains can be dispensed with.

And now allow me to say a little as to the quality of these waters in the sandstone country. They are of the purest kind, perhaps unsurpassable even by the waters of Loch Katrin, which supply Glasgow so satisfactorily, and which emanate from a granite country entirely. The sandstones overlying our coal formations in that high region are about 800 to 900 feet over the coal seams, and are free from all coaly and other shales. In my survey I observed no departure from the one uniform sandstone formation, and quite free, as far as I could see, from those occasional dykes of trap rock which are to be found in this formation nearer the ironstone ore seams which overlie the coal seams at some 500 to 600 feet, and which might, if present, tend to discolour and to make the waters hard and impure. But I saw nothing of this in the Madden's Plains region; and, for the sake of practical evidence of their brightness, I would inform this Society of a little crucial test I adopted on these waters. I was so struck with their extraordinary clearness in all the running creeks of that region that I tried the effect of tying a coin to a long piece of thread, and lowered it into a waterhole, 5 feet 6 inches deep. The day was clear, the coin at the bottom of the waterhole was of course magnified by being seen through the medium of water, and it was illusively thrown forward a long way by the angle of refraction, but when settled at the bottom the stamp impressions continued to be as clear to the eye as if it were on the surface.

These waters, from coming in contact with nothing but clean and filtering sandstones, are perfectly free from all hardness for washing or for household purposes. It was estimated some time ago in London, that if the waters brought to that city from the calcareous country around were as free from hardness as the Glasgow waters obtained from the granite country, there would be an annual saving to the Londoners of £250,000 worth of soda and soap extravagantly lavished there every year beyond the relative proportions of same diturents used in Glasgow.

As the Madden Plains and Port Hacking River and all the other streams of the regions comprised in my scheme have no abominable Wainamatta shales to pass through, nor ever touch clay soils, so would they all enter my proposed high and low delivery mains for Sydney and its suburbs in precisely the same beautiful condition; and even their transmission through the iron mains would not affect them, as I should propose to coat the mains inside by a bright, effective, and inexpensive enamel, composed of certain resins dissolved in cheap methylated wood spirit, and burnt on to the inner surface of the mains.

For ocular demonstration of the purity of such waters, I have the pleasure to lay upon the table a bottle of this water, bottled six weeks ago, and from it the Society may judge whether I have extolled those waters more than they deserve.

So much then for the water supply generally. From all I have seen of the watersheds above alluded to, in my respective trial surveys for the Illawarra Railway and for the water supply, but more particularly from the astounding positions I have lately seen for the making of grand artificial deep-water lakes, and with the facilities presented of leading large extra supplies of waters into them, there is not the slightest question in my mind as to our means of possessing the grandest and cheapest water supply that any city in the world might covet, either by reason of its quantity, its quality, or of its availability for hydraulic power.

There remains therefore, I think, nothing to be considered but the expense of my proposed method of supplying all Sydney and all its suburbs with a superabundance of the purest waters by direct gravitation, in wrought-iron or perhaps wrought-steel piping for the high-delivery mains, and in iron mains for the low delivery; also to consider the expenses of the two large concrete dams at the Loddon and in Port Hacking River, the other smaller tributary dams, the one tunnel and the open canal of about four miles from the outlet of such tunnel to the high-delivery inlet of the mains for Petersham and Waverley,, and say 6 miles more of open aqueduct for the north-westerly acquisition of waters from the higher parts of the south coast range.

The above enumeration of works constitutes the whole source of expenditure as far as Sydney, where suitable reservoirs would have to be made at Waverley and at Petersham in the onset for the high deliveries, and anywhere else in lower Sydney for the low delivery from Port Hacking valley, but which latter might be postponed for a few years until the Botany works might fail to be sufficient to supply the lower demands of the city, although assisted from Waverley or Petersham to relieve the rapidly increasing wants on the higher levels and the distant suburbs in every direction, or perhaps only until the monthly increasing evil of pollution of the Lachlan swamps will make it compulsory to shut off that source of supply, excepting for the commonest of purposes—such as for mill uses and the watering of the streets.

Let us now consider the few works under my scheme separately. And first as to the means of great storages, and of leading the extra waters into the one large reservoir on the Loddon. The open aqueduct would be run to the back of Wonona, or say six miles (for present times) from the Loddon swamps and reservoir. I propose that such aqueduct should be cut 10 feet deep, 6 feet wide, and tapered down in the sandstone rock to 1 foot width at the base. The expense of this would be nothing formidable as a national work, even at present prices of labour, and it would be calculated at so much per cubic yard.

Secondly comes the great Loddon dam, in solid concrete, to be made, by my proposal, precisely in the manner adopted by the famous engineer Mr. Ritter, in his splendid waterworks at Freiburg in Switzerland. The spot I have selected as the position for this work is admirably adapted for such an operation. The gorge of the valley that constitutes the natural egress for the waters of the great basin above is so narrow here that it is only eight chains in width across the rivulet at an elevation of 30 feet; but in order to store far more water than would be obtained by a 30 feet high dam, I have marked it off to the top level of the abutting ridge, which would make the dam 46 feet over midstream, and where the waters run over a plateau of bare sandstone rocks admirably adapted for sinking a deep concrete foundation. Consequently, to carry the top level of this dam for these extra 16 feet, it would be necessary to elongate the whole work from end to end to 18 chains to where the levels on both sides would taper off to nothing.

The object I have in view for proposing to raise this dam so high and to be in solid concrete is—first, to be able to turn the overflow flood waters over the side of the eastern ridge into a hollow that leads into another creek, and thus save the risk of damage by the flood waters going over the dam itself. Secondly, to gain immense additional catchment waters, which would create an artificial lake, at a cost which would pay for covering with deep water from 1,200 to 1,400 acres of country free from timber, and which lake would be at the mean depth of 22 feet. This lake would be about 1,120 feet over the sea.

With regard to the expense of this most important structure, I have one practical guide only, and that is the work of a similar nature built at Freiburg. That dam is 509 feet long and 72 feet high, whereas the one I propose would be only 46 feet high (plus the sinking and erections for a perfect foundation), but proportionately so much longer that it would probably contain about the same number of cubic yards of work, and which at Freiburg is 83,714 cubic yards. The expense of that concrete dam was computed at £14,600, including its sluices in cast iron, &c. Now, *cæteris paribus*, and allowing for the great difference in the price of labour, the Loddon dam of same structure might reach from £20,000 to £25,000, and a similar dam in Port Hacking valley, at 35 feet high, and about 500 feet across, might be estimated at £15,000 at most, with its sluices built in.

The other and minor dams, with only concrete cores, would be of comparatively very small expense, and the whole set of them might be estimated at £15,000.

Next to these dams, costing some £65,000, but which may be far short of the cost here, comes the one tunnel of 3 miles and 35 chains, which would be all cut out of solid sandstone, and would be available for excavation by shafts at five different spots, besides at the two ends; hence the advantage of the westerly dip, which reduces depth of sinkings. As the velocity to be given to the waters in the tunnel would be by a gradient of 4½ feet to the mile, besides the head of water at the inlet, there would be no necessity of using cement or masonry anywhere along its course. What the cost of this work would be I know not, and must leave to others to determine.

To many this underground work of 3½ miles may seem to be very great, therefore it may be desirable to mention that in the Nepean scheme, which was adopted by the Water Commission, they start at 63 miles from Sydney with one tunnel of 4 miles and 49 chains, and have in all ten tunnels aggregating 10 miles and 7 chains, besides 10 miles of 46-inch diameter iron mains and over 3,000 feet of iron aqueducts in the first 17 miles of the total 63 miles to Sydney; whereas, by my short-cut scheme on the high levels, I have only the one tunnel, and do not require a single foot of iron aqueducts in the ranges before the waters enter the long mains of 28 miles to Sydney.

Following my proposed work comes the open aqueduct for 4 miles, to the delivery mains on the Bottleforest Road, at 28 miles from Sydney. This aqueduct would be constructed like the north-west feeding aqueduct to the great reservoir, and would be all cut out of solid sandstone, with a gradient of 5 feet to the mile. The expenses of this work would be a matter for tender.

Beyond the above simple works as compared with other water schemes, and viewed as a national undertaking and for such an achievement, there would remain the large and chief cost of the two high delivery over-ground mains, in wrought-iron or in steel, of 18 inches diameter—these to run side by side as far as Cook's River, on their way to deliver respectively 4,270,891 gallons daily to the Petersham and Canterbury heights, and 4,029,143 galls. daily to Waverley, with the respective heads of water of 850 and 750 feet, as computed by Eytelwein's formula; and these two high delivery mains to be coupled together by union joints above where they would part company at Cook's River, so that in case of necessary repairs to either pipe the other could go on serving both Petersham and Waverley alternately; and then would remain also the low delivery main from about 22 miles from Sydney in the Port Hacking Valley. This main is proposed to be of 36-inch diameter, estimated to deliver 5,407,533 gallons daily to some reservoir of the same level as Crown-street, if not into that reservoir itself. In all 13,717,567 gallons.

Here again, for these mains, I am unable to arrive at any satisfactory estimate. All I know is that there are engineering firms here that would be ready to contract for the manufacture of all the mains as fast as they can be wanted. But this much I think I may venture to say, that as three such pipes as I propose for adoption would deliver say twelve (12) millions of gallons of water per day, this would be making provision for a supply and delivery to a population of 300,000 at 40 gallons per head per day, besides having storage and means of supply (less the additional mains) for a full million of a future population, in the works at the sources of supply, and supposed to be completed under my estimate.

However, let us charge the whole of the proposed works on a population of only 300,000, which Sydney and its suburbs may have in perhaps less than ten years more ; and let us charge that population with an expenditure on these works of only 40s. per head, and we have the sum of £600,000, which I should think would be quite equal to the total expenditure on my scheme for a delivery of 12,000,000 gallons of water daily, with means to increase the supply to a very much larger extent. But admitting the possibilty of any under-estimate in the cost of my proposed water scheme, we may be satisfied to pay more for the development of a scheme which will give us a pure and abundant supply of water by direct gravitation, and which will also afford immense hydraulic power, besides having the means of trebling the supply. Let it be remembered that in London, where material and labour is or was cheap, there the cost of the various water supply works represented a capital, before the great rise in iron and labour, equal to £10,137,000, a sum which represented an expenditure of 60s. and not 40s. a head upon the then population of that great city, and to which population filtered water is delivered at the rate of £26 per 1,000,000 gallons, or at an average cost of *about the fortieth part of a farthing per gallon*, or say ¼d. per day, or 7s. 7¼d. per annum, for the average consumption of even 40 gallons per day ; and yet the eight Water Companies in London return handsome interest of money on their works and capital invested. Whereas, in Sydney, our water rates, for unfiltered and impure supplies, are preposterously in excess of this ; and the cheap blessing that is or should be at our command is denied to us, and is still rendered prohibitory for most manufacturing purposes, and weighs heavily upon the population, by reason of the high rate rates of 5s. charged on every room of every description attached to every dwelling, even whether water be laid on or not; and of no less than 7½d. per 250 gallons, or at the rate of £125 per 1,000,000 gallons by meter measurement, as against £26 in London for same quantity of filtered water.

And now I would wish to say a few words here on the subject of the value of the hydraulic pressure and power which will be available by the adoption of my water scheme. My plan is wholly a gravitation scheme; and having learnt by the development of the Nevada Waterworks, as published in the *Engineer* of the 3rd of April last, and copied into the *Sydney Mail* of the 18th July, that wrought-iron pipes there of only 5-16ths of an inch, in boiler-plates worked into pipes of 11½ inches diameter, bear the before unheard of pressure of 750 lbs. to the square inch,—so I have considered that we should avail ourselves here of the high pressure at our command, from near Madden's Plains, with 1,050 feet head of water at sea level, as against 1,720 at the Nevada Waterworks; as we should be enabled to use smaller pipes and cheaper pipes, by reason of the great velocity that would be given to the waters under such a tremendous head of water, and yet to be quite safe from bursting when made of boiler-plates of iron, but better still in steel, varying according to elevation and pressure from 2-16ths to 3-16ths and 4-16ths of an inch in thickness only.

With such hydraulic pressure for quick delivery we could avail ourselves in Sydney and in Port Hacking valley of this valuable force, and turn it to account in various ways for hydraulic lifts, turbines, &c., but most advantageously so by applying it to the compression of air as the indirect motive power to send the sewage and waste waters of the city on to suitable positions for irrigation, in same manner as you will find partially described in Delabar's paper on Ritter's great works. Ritter was the inventor of this method and applied it for the first time at Freiburg quite recently. I may mention here that his method of freeing cities or towns from sewage and waste waters seems to be superior even to Capt. Liernur's admirable plan of effecting much the same results, and whose system now is so extensively adopted in many large continental cities. The difference between the two systems is that Liernur draws away all sewage by forming a partial vacuum in the sewers by a steam-engine acting on a large air-pump, and so brings away the sewage at will to certain centres, for its evaporation into *poudrette*, which is packed in casks and sent off into the country, where it is bought with avidity by the farmers, who have discovered that it is more valuable than the best guano. This system is found to answer very well, and it pays to produce this now highly prized manure, at the same time that it keeps the towns which are treated by Liernur's process in a perfect state of purity and salubrity.

Ritter, on the other hand, produces the same results in a far superior way, by collecting the sewage and the waste waters as they come away from the houses; they are brought to two centres in the town, wherefrom and by a valuable application of a part of the great hydraulic power which he has at his command he rids the city of everything both liquid and solid from the sewers, and sends it all to a great distance outside the city and high up on to lands in two different directions, where systematic irrigation is constantly maintained and with important results. This enterprise is found to pay those interested there in Ritter's grand application of the compression of air through hydraulic force.

Practically we might compare the two systems to the principle of the syringe. Liernur's system *draws* the sewage into the partial vacuum, whilst Ritter's is the counterpart of the action of the same syringe, and *drives* all before it by the action of the piston compressing the air.

I should apologize for the above digression from the direct subject under consideration, did I not conceive that my proposed high pressure delivery of the waters, and which would constitute a large portion of my proposed supplies, has a most significant bearing on the value of my scheme for giving such valuable motory power without any necessary waste of the waters used to create such action; whilst, at the same time, the high pressure would give such quick delivery of pure water into the city that pipes of less than half the size and weight would deliver as much water from my proposed in-take elevation of 1,050 feet at the mains as could be delivered by the low-level operation from the large and heavy main out of the Port Hacking River from an elevation there of only 170 feet over the sea, or (say) 34 feet above the level of the Crown-street Reservoir, from whence I propose to take in those lower waters.

In connection with such proposed available water-power, as well as for the diffusion of useful and interesting knowledge, I have the pleasure of laying on the table of this Society my recent translation from the German of Mr. Engineer Delabar's most interesting paper on Ritter's Waterworks at Freiburg; it is taken from *Dingler's Polytechnical Journal*, a work of celebrity in Germany. I would propose that this translation be attached to this water supply paper as an appendix to the same, and taken as read; because I consider that whatever thought I have given to the development of my water scheme I owe much of its origination to my having been favoured with the possession and reading of such a valuable paper—a paper which gives evidence throughout its every page of the power of the great master mind that designed and carried into execution the noble and varied works recently undertaken, and now in full operation at Freiburg.

I would gladly read the paper to this Society as an appendix to my own present lecture, so entirely is it fraught with matter that would interest you much on the present occasion, but it would occupy too much time to do so, and I fear I may have already trespassed on your patience. But there is so much in that paper which has helped me to think out my present water supply scheme, that I consider it to be, in a measure, as inseparable to the proper understanding of my present paper as I must consider the affiliation of the proposed Illawarra Railway to be as indispensable to the easy development of the Sydney water supply by gravitation.

With these papers I also leave on the table a copy of the map of my late survey for the water supply, which will facilitate the understanding of my whole scheme very materially. I have tried by such map to make it so clear to intelligent minds that it should require no further explanations than what I have shown and written on its face. All the works required in my design are mainly shown on the breadth of the map, which represents only 7 miles of country. The other works that are proposed and which are not upon it, are simply the extension of the north-westerly canal or aqueduct for 6 miles towards the direction of the western slopes of Wonona, and the great concrete dam proposed to be erected where the waters pass through a level and narrow gorge in the Port Hacking valley, and where the waters are at an elevation of 149 to 150 feet over the sea level at high-water-mark, and which would be some distance below the lowest free selections on the river.

In presenting my map to this Society, I desire to explain why there should be any elevations shown upon it to have been taken by the aneroid, and not with the level and staff. Fortunately nearly all of them were taken with the proper instruments; but when the survey was nearly completed, my assistant in the work and I both became disabled from illness; therefore, and to save useless expenses, I disbanded my party, sent the heavy instruments back to Sydney, and postponed the completion of the work; but we finished it later very satisfactorily by means of an excellent aneroid.

In submitting this paper to the free discussions of this Society, I desire to say that in all I have advanced, either for the Illawarra Railway development or for this proposed water supply, I have been actuated by no interested motives. I have only had the good of all in view, and therefore I hope I may be excused if I avail myself of this opportunity of saying that, having given so much thought to the consideration of these matters, I may be supposed to have thoroughly digested the subjects, and that I do hope that no pressure of petitions from interested parties will be allowed to bear with the public or on the Government for any departure from the prescribed route of the intended Illawarra Railway in its direct course to its only true and legitimate terminus for a future great coal trade, namely, at North Balmain, as now surveyed,—any deviation from which would I feel sure be a fatal mistake.

I also desire here to repeat my belief and hope, publicly expressed in my first railway paper, read before this Society on 6th of August, 1873, that the northern connection of the Maitland, Newcastle, and Lake Macquarie trades with the harbour of Port Jackson, at the North Shore, opposite Cockatoo Island, may speedily follow in the present awakening spirit of progress.

And now with reference to this water supply scheme, I trust it will not be thought that I am actuated by any ungenerous motives towards the designers of the other grand schemes. When the Water Commission prosecuted their labours several years ago the Illawarra Railway was not thought of, and consequently the Port Hacking River north of Bulgo and east of the Illawarra Road was never visited by the Commission, nor was any union of those waters or those of the head of George's River and of the Waranora with the south coast waters then contemplated. It is therefore to the development of the Illawarra Railway that we owe that natural enlightenment which has led to the discovery of a most valuable water supply for Sydney, wholly to be brought about by availing ourselves of Nature's simple laws, and of following her own gravitation principle of the north-westerly dips of her great coal basin at our doors.

Such are my ideas towards the designers of the other water schemes, and towards the gentlemen who constituted the Water Commission of 1869. And on my own behalf, I rely confidently on the language of the Commission, towards the end of their Report to the Government, when they made the following remarks :—"We now invite the closest scrutiny of our results, sensible that if our scheme (the Nepean) be in the main the best attainable, it will be improved by passing through the ordeal of enlightened criticism ; while if any better scheme still lies undiscovered, this same criticism will, we trust, bring it to light."

Finally, then, with such high-minded remarks from the gentlemen of the Water Commission, I need not hesitate to say that, in advancing my own gravitation water supply scheme before this Society and before the public, I do rely upon its substantial excellence by reason of its being based on geological deductions. I rely on the natural features of its locality for abundant water supply and abundant storage, far more than on any useless amount of excessive watershed in a droughty climate. I rely on its comparative inexpensiveness; on its perfect freedom from all harassing compensations; on the unsullied purity of its waters for delivery; on its short cut course for Sydney; and on its great simplicity, which may cause the works, if my scheme be adopted by the Country, to be completed within the same time that the Illawarra Railway,—if simultaneously undertaken,—can be ready for traffic to Wollongong.

NOTE REFERRED TO AT PAGE 46.

At this part of my paper I would desire to attract more and special attention to the great advantages that we have at our command by the valuable north-westerly dip of the immense Sydney coal basin, and quite apart from our appreciation of all its vast coal-bearing importance.

In the hopes then of conveying to your minds the full force of our geological advantages for the production of an immense and constantly running supply of the purest of waters, I would wish to point out facts which are probably unknown to many who are present.

Our sandstones which overlie our coal on the Illawarra ranges are the same as the *grès houiller* of the French, and the *kohlen sandstein* of the Germans; they not only dip inland and towards Sydney, but they possess (for us) the additional advantage of being more stratified and not so compact as are the *Old red*, the *Exeter red*, and most other sandstones and conglomerates; and therefore our formation can readily give off its accumulation of waters constantly and slowly by its easy fall of 2 degrees west, when the stratifications would be intersected by my proposed supply aqueduct, and by the delivery tunnel and delivery aqueduct as far as to the iron mains at 1,050 feet elevation.

In order that we should appreciate fully the immense value of the stratifications, and of the extremely light north-westerly dip of our Illawarra ranges, for the benefit of a grand water supply for Sydney, we should do well to compare our own good fortune in this respect with that of other extensive countries on the coast of the Mediterranean, and especially along the northern parts of Palestine.

The dip of the formations there is the same as ours, only that there the sea is on the west of Palestine, whilst we have it on the east; and their stratifications are probably much steeper than ours, and dip into the sea, whilst ours dip inland; at same time, the formations of those parts do not belong to our close and stratified sandstone class, but belong to the Jurassic formation, which is chiefly composed of strata of marls and of porous and often times cavernous limestones of the oolitic kind. The consequence of this great difference is, and as we are told by the Syrian missionary, Dr. W. M. Thomson, in his work entitled "Land and the Book," (at page 181), that along the northern coast of Palestine, especially by Sidon and Tyre, "the waters during the rainy months pass off by the strata into the sea by innumerable streams, and with such peculiar force that at Ruad, the Arvad of the Bible, a fountain bursts up from the bottom of the sea, of such enormous size and power as to make the whole surface to boil like a cauldron"

Should not then this comparison cause us to rejoice at our great and superior advantage of having our stratified coal sandstones at high elevations over the sea, receiving the rains openmouthed from even the extreme easterly projecting cliffs towards the ocean, and from whence the pure waters are slowly conveyed to the opposite, inland, and western side of the coast range, by Nature's own gravitation principle in these parts, and through the north-westerly dip?

Here, in the long and high coast range of Illawarra, would be our greatest storage reservoir, where our supplies would be so well retained for us, and be ready in boundless quantities for our future Sydney use, by the adoption of my simple principle of tapping our enormous sandstone filter for miles and miles when required, along a base line and section that we could cut at such elevation as would suit our own gravitation scheme of conducting a new river that might thus be formed and sent into the great Loddon Reservoir.

I sincerely trust that this elucidation of my supply, storage, and gravitation scheme may go far to settle your convictions of the magnitude and value of Nature's great gift within your reach.

APPENDIX.

[*Translated from the German, by James Manning, Esq.*]

THE NEW WATERWORKS AND INDUSTRIAL OPERATIONS AT FREIBURG IN SWITZERLAND. By G. Delabar, C.E., of St. Gallen.

As a member of the Swiss Society of Arts, which had its annual meeting at Freiburg, on the 19th, 20th, and 21st of August, 1872, I visited the prettily situated town of Freiburg, on the Saane River, and by such opportunity I became acquainted with the highly interesting waterworks and industrial enterprises which had been undertaken there in the last three years.

It is as well to remark, at once, that the soul of these undertakings was in the person of its one director (Mr. Engineer Ritter), who is a highly educated, and is at the same time a very genial and enterprising man. This gentleman has not only brought about important advantages for both sides of the town of Freiburg, but he has succeeded in gaining the confidence of the capitalists of Freiburg and of other parts of Switzerland, particularly of Basel and Winterthur, to aid him in the development of his projects.

On the 4th of October a contract was entered into between the Town Council of Freiburg and Mr. Engineer Ritter, which was confirmed on the 12th of January, 1870, by the higher Council of the Canton of Freiburg. Mr. Ritter being thus invested with full powers, the town of Freiburg sold a part of their forests, about 1,400 English acres, to Mr. Ritter, for the sum of 1,400,000 francs, equal to £66,000, and gave him at the same time authority to erect waterworks and hydraulic motive works on the river Saane; but with this proviso, that he was to supply the inhabitants of the town with an ample quantity of drinking water, as well as to furnish sufficient water power for various industrial mills and works; but all, of course, with the understanding that he should be fully compensated for his undertakings. Upon this Mr. Ritter formed a Company, which was called the "Société Générale Suisse des Eaux et Forêts." This Company allotted to Mr. Ritter no less a sum than 500,000 francs (£20,000) in paid-up shares. The Company was duly formed and incorporated by statute in Freiburg, and at which place it was to hold its future meetings. The direction of these technical and commercial works was thereon given over entirely to Mr. Ritter. In the onset the Society determined upon carrying on the following operations :—

1. The economical farming of the forest purchased from the town of Freiburg.
2. The water supply for the town.
3. The building of a dam and sluice on the river Saane, and the utilization of the water power to be thereby produced.
4. The erection of a saw-mill, and of a large workshop for the same, with a branch railway to connect it with the Freiburg Trunk Railway Line.

For the development of these works the Company's capital was required to be 2,000,000 francs (£80,000), composed of—

1,000 promoters' shares of 500 francs each =	500,000 francs.
3,000 preferential shares at 500 ,, =	1,500,000 ,,
	2,000,000

These shares were taken and allotted with the understanding that during the four building years (1870–73) the shares of both classes should bear interest at the rate of 6 per cent. and the probable profits should be so applied that 75 per cent. of these should go towards a reserve fund, and about 25 per cent. of the same should go for the declaration of dividends on both classes of shares.

Attached to the original or parent Company, Mr. Ritter brought about the formation of branch Companies for the development of fish culture, of gathering ice, and of irrigation, called the "Société de Pisciculture, Glaciers et Irrigation," which had also its centre in the town of Freiburg, and which branch Company determined on the carrying out the following projects :—

1. The erection of an establishment for fish culture, and therewith the stocking of the waters of the canton for the distance of "60 hours"—say 90 miles around.
2. The building of several ice-houses for the commercial development of ice from the river Saane.
3. The irrigation and the manuring of the lands on both the high elevations of the neighbouring places, called Perolles and Neigles, by means of the waste waters and the sewage of the town.
4. The erection of a bathing establishment, of a bleaching and washing establishment, of a swimming school in summer and of skating in winter; besides the adoption of the so-called "Lake of Perolles" and of its approaches and banks for the formation of pleasure grounds for the public.

For the development of these special undertakings, an additional capital of 400,000 francs (£16,000) was required and was allotted in—

200 promoters' shares of 500 francs each ... 100,000 francs.
600 preferential shares do. ... 300,000 „

In the first two years (1872 and 1873) only, the preferential shares received 5 per cent. interest. After those two years have passed, the promoters' shares will have interest also at 5 per cent. The probable profits will be apportioned at the rate of 20 per cent. towards a reserve fund, 20 per cent. for the directors and management, and the remaining 60 per cent. for dividends to both classes of shares.

Besides these there are other works in progress, and which are held under special arrangements with the parent Company, and which are situated on the heights of Perolles, above Freiburg, and these are:—

1. An iron foundry and engineering establishment.
2. A large railway carriage manufactory.
3. A chemical manure factory.

Besides these there are other factories in contemplation for immediate building, namely,—a paper-mill, a pottery and gypsum factory, a barley-grinding mill, and stone-cutting works, and there is no doubt that other undertakings will soon follow.

The first-named operations are of such importance and of such general interest that I may venture to say that a fuller description of them will be willingly accepted. I shall therefore try to describe them as nearly as it is possible to do so without detailed drawings and representations. For a general outline of the works, figure 1, showing a ground plan of Freiburg, will be of service; the sectional plans also, figs. 2 to 4, will help to demonstrate the dam and sluice works, the turbines and the pumping gear, and the filtering works.

The description will extend to the following works:—

1. The great dam and sluice works on the Saane.
2. The waterworks for the hydraulic motors.
3. The filter and pumping works.
4. The telodynamic cable, and wire rope transmission.
5. The saw-mill and large carpentering works, and the other industries on the plateau of Perolles.
6. The conduit of water and the reservoir of Quintzet for supplying Freiburg with drinking water.
7. The canal conduits for the irrigation, and for manuring the heights of Perolles and Neigles on both sides of the Saane.
8. The establishment of the fish culture, and the bathing places, and the ice-houses on the lake of Perolles.
9. The utilization and farming of the forest which was purchased from the town of Freiburg; and

10. The erection of a branch railway line to connect the great timber and other works with the main trunk line.

1.—The great Dam and Sluice Work. FIGS. 2 & 3.

The starting point or pivot of the whole operation is in the dam on the Saane. This is a truly grand structure, entirely constituted of cement concrete, and made for the express purpose of stopping and of backing up the waters a little above the town, south, and to dam up the waters of the river to a sufficient height to give the required power.

This gigantic monolith is built entirely of cement concrete, is erected sideways across the river for $509\frac{1}{2}$ feet; over the surface of the water it is $39\frac{1}{3}$ feet high, and from the foundation of the dam upwards it is 72 feet; the ground floor foundation is 98 feet broad, and the top of the dam is 19 feet $8\frac{1}{4}$ inches broad or thick; and it has a cubic measurement of 64,000 cubic mètres—equal to 83,714 cubic yards. This work was commenced in the year 1870, and was finished in 1872. By these colossal dimensions and by this gigantic dam we are reminded of the Roman works. Neither expense nor trouble was spared to complete the same; and to hold it harmless against all natural influences of water-pressure on the foundation, or of atmospheric action and changes from heat to cold, which might favour the decrepitation of the side wall rocks on either side of the dam or shores of the river; and no expense was spared to insure its withstanding the action of possible earthquakes over a long series of years. The geological formation of the Saane, in the neighbourhood of the dam, is similar to that of our own neighbourhood here at St. Gallon, on the Sitter. Underneath the sandstone, near the surface, signs of atmospheric action are seen; but below the waterbed there is a very durable and hard sandstone molasse; over this is a tolerably hard conglomerate, and on the top a loose swampy alluvium. Luckily, and exactly at the required spot for the dam on the river's bed, there was a cropping out of rocks and of hard stones for a height of 19 feet $8\frac{1}{4}$ inches on the most waterwearing side of the river, which gave a most excellent foundation for the work (as may be seen by looking at sectional plan, figures 2 and 3), so much so that it may be hoped that the dam may be everlasting.

A further foresight was availed of, that the surface of the rocks, upon which the foundation of the dam had to come, after the floor of the river was laid dry by pumping, was so hewn or picked as to present a succession of steps, upon which the cement work of the dam would be raised and united with the foundation rocks, so as not only to secure the greatest possible strength to the structure, but also to insure its impermeability from water pressure. This work of cutting, or rather of picking out, was considered to be of the greatest consequence, as may be imagined when we find that the surface of the foundation exceeded 1 acre.

An idea of the difficulties that were attendant on the building of this dam may be formed, when we are told that in getting the foundation alone built there were five locomotive engines and eight centrifugal pumps kept going night and day, and every day, for a long period, as method of keeping the waters lifted and diverted from the foundation by means of a tunnel through the range at the side. It is a source of congratulation that this cement concrete work has here proved its efficacy. The pebbles in the river, together with the stone in the immediate position of the dam, were mixed with hydraulic cement, sand, and water, into a concrete, which was immediately laid in its place on the works. The cement came in the usual form of casks of cement, whilst the pebbles, the stone, and the sand were obtained from the bed of the river in any required quantity. Last winter, and under the severest cold, but assisted by some warming appliances, the work was carried on uninterruptedly and prosperously.

The sluice-gate with the inlet canal for the outflow and for the occasional cleaning out of the new lake of Perolles is now finished. A casting, which is 23 feet long, 8 feet 2 inches broad, and 8 to 11½ inches thick, serves for the basis of the same. It is formed out of one vertical cast-iron frame, made from four pieces of T-formed shape, in which a guideway wall is set, and which is made out of 7 inch square timbers of oak. The tunnel, which is cut through the rocks on the left side of the dam, was for the purpose of diverting the waters of the river whilst the dam was building, is now about to be closed again.

Through this damming up of the Saane the waters, which have a flow equal to 30 cubic mètres, equal to 6,617½ gallons per second of time, are raised 34⅓ feet to 39⅓, and thereby a disposable water-power is obtained which is equal to 2,600 and up to 4,000 horse-power.

By this embanking the water is at the same time thrown back over a considerable surface, much in the same way that we observe the formation of lakes in our Alpine country; and through the swelling and backing up of the waters a new lake has been formed which Mr. Ritter has named the "artificial lake of Perolles"; but it is expected that the present depth of the lake at starting will not be maintained, because of the sediments of sand and earth masses, which in course of many years will be sure to affect its depth. However, the flow of water per second of time through the artificial fall will not thereby be altered, and therefore the disposable power will remain unchanged.

The upper surface of the lake is about 3,280 yards long and 197 yards wide, and it covers an area of over 774,715 square yards, or about equal to 160 English acres. The whole cost of the dam and sluice works was estimated at £14,600, and the estimate is not likely to be overstepped by the actual expenditure. Up to the end of last year's balancing of accounts, and when the work was nearly completed, the expenditure on the same had been only £13,247. This fortunate calculation of the estimates is owing to the foresight and knowledge of the director, and so also the estimate of the value of the building materials, the stone, the pebbles, sand, &c., in the neighbourhood of the place, proved that the cost of each cubic mètre of cement concrete (1·334 cubic yards) did not exceed from 5s. 10d. to 6s. 8d.

2.—The Waterworks for the Hydraulic Motors. Fig. 3.

By reason of the above described dam and sluice work, as already stated, the raising of the Saane water to from 33 to 39 feet, the enormous force of from 2,600 to 4,000 horse-power is obtained. For the perfect utilization of this enormous water-power a number of turbines, after the system of Girard, are adopted, in which the water is led through the canal A, B, C, D (fig. 2), which is 54 feet 1 inch broad. Up to the present time only two turbines are laid on. These as well as the other driving machinery were made at Winterthur. The other water space or room, now in progress of building, is planned to carry four turbines, and in all probability it will soon become necessary that the other and further intended two turbines should also be carried out.

From the 1,200 horse-power which will be obtained through these turbines, 600 horse-power will be taken for the driving of those works which are already in progress of erection, and 600 horse-power will be reserved for the lifting of the drinking water into the high-level reservoir at Quintzet, which is 525 feet above the dam. For the commencement, and as long as there are only two turbines at work, there will only be the half of this disposable power given to these undertakings.

For the transmission of the mechanical driving power of those industrial works which are now getting ready, and for others that are in contemplation, the so-called telodynamic cable will be brought to bear; these we shall describe more particularly in our 4th division of this paper. For the lifting of the drinking water to the high-level reservoir at Quintzet, four of Girard's double pumps will be applied, besides the cast-iron piping which we will describe more closely in our 6th division. The above-named four pumps will be made at Vevay, on the lake of Geneva, and the piping at Solothurn.

The building for the turbines and pumps will be 152½ feet long and 73 feet broad, and is to be entirely brought up from a rocky foundation. It will be attached immediately to the east end of the dam (see sectional drawing in fig. 3), by which you may see the relative position of the turbine and pumping-house, with the inlet canal and the inlet pipes, besides the other leading pipes of the dam and sluice works. By reason of the floods which took place in the spring of this year (1872) the erection of this building was very much delayed. During the late summer the works have made great strides, and it is hoped to have this important building for the waterworks covered before the cold winter sets in. Besides this it is confidently expected that the mounting of the turbines and the wire-rope transmissions of power will be completed this year (1872). The pumps and the iron piping for the water supply must be completed, according to contract, by next spring, and be in actual working order.

Thus by these measures the inhabitants and the industries of the town of Freiburg have been most specially cared for, with pure drinking water for their houses, and with water-power for their industries, given them to such an extent that their great advantages will become the envy of far more important towns. In fact nothing more noble can be conceived than these waterworks which are perfected for the sole purpose of making water subservient to man's use—for his home, for his fields, and for his industries in life.

According to the estimates, the two turbines, the four pumps, the inlet canals, and the double buildings were rated in the first instance at 175,000 frs. (£7,000). Up to the present time the cost by the balancing of accounts gives only 68,272 frs. 27 cents. (£2,730 17s. 10d.) for the buildings, £1,840 for the two turbines, and £314 for the four pumps, or, altogether, not quite £4,880,—so that the estimate for these are not likely to be overstepped by actual expenditure. This favourable result has been very much brought about by the fact that the waterworks could be entirely based on a rocky foundation, and that the necessary hewn blocks of stone for the building were easily obtained on the spot. These, for instance, were to be had from the excavations of the outlet canals and of the turbine house, and generally out of the excavations that were necessary to be made in connection with the works.

3.—The Filter and Pumping Works. Fig. 4.

In the dammed-up waters of the lake, and behind the dam and sluice works, there is a large tower-like vessel, made out of sheet iron, which contains the filter for the water intended to pass through it. This iron vessel has a diameter of 19½ feet, and is 16½ feet deep. It is set up on the gravel beds of the Saane. Inside it there is a circular casing of 1 feet 11⅗ inches thickness, which is made of cement, in order to protect the inner filtered waters from coming in contact with the outer waters. The remaining vacant space is filled up with the filtering medium, which is composed of various layers of coarse and fine gravel and of sand, whilst above is the filtered water of the Saane and the clear spring water which was discovered by the building of the dam and sluice works. That clear water from the spring, which is led in by a cement pipe of peculiar shape, forms no inconsiderable part of the supply of drinking water for the town. A further part of the supply required for the use of the town is obtained by filtering the waters of the Saane, which have to pass through the various levels of coarse and fine pebbles and of sand, and become perfectly pure. In order to arrive at this issue more easily the tower-shaped vessel is surrounded with suitable stone and gravel beds, and these are supported by a horizontal bed of cement, from the under parts of which they are made impervious. (See section sketch, fig. 4.) In the same manner the piping through the underground canal is connected with the filtering works and with the pumping work in the south-west wing of the turbine house, where there is a shaft, in which the water comes in by natural pressure from the lake and where the pumps suck it up. All this is well made, and the further introduction of discoloured water is guarded against. In order to prevent the cloudy water of the lake from entering the filter, the upper part of the arrangement is closed, but in order that the level of the purified waters may rise and fall inside, there is a long open pipe (see fig. 4) placed on the filter, which in this way keeps up a constant connection with the outer air. By means of the pumps, when the works are all finished, the drinking water that is collected in the water vessel will be forced up 160 mètres, 525 feet, to the high reservoir at Quintzet, the highest point of Perolles, from whence it will afterwards be conducted by its own gravitation to all parts of the town of Freiburg.

The filtering works, with the connecting canal of the pumps, have been finished for a long time; and the experience of this spring during the thawing weather, and the freshes in the river which produced much muddy water, goes to prove how very excellent have been the arrangements for the filtering, inasmuch as only water as clear as crystal, and no discoloured water, is delivered into the town. But how long this present perfect working of the filter may last is another question which the future will only be able to determine. But it is certain that the great advantages of the present excellent filtering arrangements are never likely to be hereafter lost for the possible necessity of renewing them. The whole estimate for the filtering works was £2,000 at the commencement, whilst the actual cost of the same, from the last statement of the director (Mr. Ritter), only came to £1,366 8s. 10d.

4.—The Telodynamic, or Wire-rope Transmission.

FIGURES 1 AND 3.

For the present the first telodynamic cable of 765 mètres (2,510 ft.) is ordered to be made after the pattern of that one which the firm of Ricter & Co., of Schaffhausen, made, and of which sort others have been in use elsewhere for many years. This cable is to communicate motive power from the turbines, to the extent of 300 horse-power, on to the plateau of Perolles, for the use of the various industrial establishments that are already erected or in progress of erection. For this purpose the cable is made out of very strong wires, and is to be an endless cable, which will play over suitable iron rollers fastened on to strong stone pillars, which will have cast-iron bed plates (fig. 1). These will be put in motion by the turbines (fig. 3); and by this means the motive power will be carried forward wherever wanted for driving the machinery of the various industrial operations. The whole length of the cable, from the turbine house in the valley up to the saw-mills on the heights of Perolles, is divided into five stations, of 153 mètres each (510 ft.) The cable itself is a wire rope of 3 centimètres ($1\frac{1}{6}$ inch), and runs over bearing rollers of 4·5 mètres ($14\frac{1}{2}$ ft.) in diameter. The supporting pillars for the rollers are built of massive stones, and are of different lengths, according to the various depressions or elevations on the line; the highest of these, which is at the 4th station, is $80\frac{2}{3}$ ft. high. In consequence of the great slope or declivity on which it was necessary to conduct the wire rope transmission from the valley of the Saane up to the various works, it became necessary to fill up some depressions, and to make excavations for the even course of the transmission power; and even for some distance the transmission had to be conducted through rocks by means of a parabolic tunnel. By these precautions it was rendered possible to have the traction on an even gradient of only 10·7 per cent.

The first bearing roller is directly in the turbine house, and is at an elevation of $10\frac{1}{2}$ feet over the surface of the water of the outlet canal. The pillar of the first station, as may be seen by the plan and fig. 1, was built on the rocks, between the old and the new bed of the river Saane, and indicates an elevation of $29\frac{1}{4}$ ft. The support of the bearing roller of the second station is borne by the rocks of the tunnel itself. The pillar of the third station, although of an unimportant height, is being built on a projecting rock; the same of the pillar of the fourth station, which is, as already stated, the highest of the whole, and is $80\frac{2}{3}$ ft. The bearing roller for the 5th station is brought direct into the building of the saw-mill.

The bearing rollers and pillars for the three first stations are intended for a second cable, and are reckoned to produce an effect of 600 h.-p. From the third pillar the transmission branches off in two lines: the first, as stated, goes over No. 4 pillar to the saw-mill; and the other passes along to the railway carriage manufactory. These two end stations are connected by a third line, which stretches from the saw-mill downwards to the ice houses on the Saane, and on the other side of the carriage factory on to the foundry and engineering shop, and thence to the chemical manure making works.

A second cable, for which the pillars are already erected, is planned for the direction of the lower town, and next to the projected paper mill, &c.

The whole erection of the cables, together with the turbines, are given by contract to the firm of Ricter & Co., of Winterthur, and are already nearly finished. The cost was at first estimated at £2,000. This sum is however considerably overstepped, inasmuch as the director's last statement of accounts showed the cost of the cables to have already reached £2,662 17s. 2d. These extra costs beyond the estimate arose in this way: that it was determined during the progress of the work to start the foundations of the pillars directly upon the rocks themselves, instead of building them as first intended upon the alluvial formation which overlies the rocks; but this proves to be money well spent, because so much of the well maintained transmissive power by the cables depends upon the solidity of the under structures, and consequently would be so much more economical and satisfactory for the driving of the machinery of the different operations carrying on upon the plateau of Perolles, and in the valley of the lower town.

5.—The Industrial Works on the Plateau of Perolles.

We have now more specially to speak of the various industrial works, which are ready, and of others that are nearly ready for operation, and which are situated on the heights of Perolles, and close to the Freiburg Railway which leads to Lausaune.

a. The saw-mill and great carpenters' shop.
b. The railway carriage manufactory.
c. The foundry and engineering works, and—
d. The chemical manure works.

The first of these factories is the mechanical saw-mill and carpenters' shop, and this is retained in the interest of the parent Company (Société Générale Suisse des Eaux et Forêts) in order that they may have under their own control the economical use of their own forest timber, besides having at their own command the profits to arise out of the sawing and the cutting up of the timber. The building that they have erected for this purpose is 282 feet long, 131 feet broad on the ground floor, and where the saws and the other machines are erected it is 24½ feet high; on the west side there is a building attached $32\frac{3}{4}$ feet broad, which is for the offices and stores. The distance of this factory from the railway is 2,296 feet, and 2,510 feet from the turbine house, as already stated. The first cable is used for driving the saws and other carpentering machines, and which cable up to this station has an effective power equal to 300 horses, and is availed of as required.

Out of the number of the twelve saws and cutting machines with which this factory is to be provided, the large breaking down saw was finished, and was in full work all last summer, and for the then and present working of which, two locomotive engines were used. It is expected that in November next (1873), the building and all the erection of the machinery will be finished; and as these latter gradually get into work, so will the returns from the Company's forest lands come in more and more. Already, it may be thought, from this brief notice, that this special factory will be of the greatest consequence to the whole undertaking, and with these expectations it has undergone such expansion as is probably not equalled by any other similar establishment.

The next factory lies a little nearer the railway. This is the railway carriage factory, and was erected by a branch Company. This establishment is not of less importance than the first-named one. For the driving power of the various machines for these works, a part of the power of the first or saw-mill cable is used, besides the direct application of the second cable to this factory. According to contract lately entered into between this branch and the parent Company, a motive power of 50 to 150 h.-p. is provided, and the contract embraces the annual sale of from 2,000 to 3,000 cubic mètres (2,616 to 3,924 cubic yards) of sawn timber from the saw-mills for the express use of this railway-carriage factory—a quantity that will take one-seventh part of the whole year's production of the forest. This establishment has also a most promising future before it, not only from its profitable purchases of timber from the adjacent saw-mills, but also from its prospects of great returns by the sale and transport of their finished railway carriages, under the very advantageous position of being immediately by or on one of the most frequented railways on the Continent.

In like manner are the prospects of the next or third establishment, namely, the foundry and engineering works. This is situated still nearer the railway station and on the junction line. Its operations will be a great necessity for the carrying out of the various new industrial works at Freiburg. For this reason these engineering works have already been nearly a year in full operation, and when the wire-rope transmission power is in full working order it will demand a motive power from it equal to twenty horses.

The price of the motive power, for the present, is at the rate of 150 to 200 francs (£6 to £10) per annum for each horse-power, according to the greater or lesser power demanded by each individual establishment. Beyond the four above-named works, others are in contemplation in the so-called "Undertown" of Freiburg on the Saane, namely, a paper manufactory; further on a gypsum and pottery factory; and on the heights of Perolles a stone-sawing mill, and a barley-grinding mill; and I am convinced that when once the above-named works get into full operation many others such will follow.

In connection with the gypsum works, which, as well as the clay pottery, are situated in the valley of the Saane and near the ice-houses, it may be mentioned here that the Company have discovered a rich deposit of gypsum, the raw material from which is converted into use by both pulverizing it for manure and by calcining it for making plaster of Paris of it. The gypsum fabric is connected with clay pottery works, so as to keep the regular staff of men continuously employed—the gypsum for the winter, and the pottery works for the summer.

6.—The Waterworks and Reservoir on the heights of Quintzet for the supply of Drinking Water for the Town of Freiburg.

The waterworks for supplying Freiburg with good drinking water is divided into the lifting and into the delivery transmission. The lifting work extends from the pumping at the hydraulic workshop on the Saane to the reservoir on the highest point of Perolles; whilst the delivery starts downwards from the Perolles reservoir to the remotest parts of the undertown of Freiburg. As already stated, this lifting operation of sending waters from the Saane up to the reservoir at Quintzet is done by four of Girard's double pumps, which will be driven by either one or two of the turbines. From the reservoir on the heights of Perolles or Quintzet down to the remotest parts of the town, the operation will be simply by the gravitation and the pressure of the water itself.

The quantity of water which these four pumps will deliver every minute is estimated to reach 3,100 litres (682 gallons). This quantity of pure drinking water will be equal to a quarter of the total water consumption of the town, when once the whole population avail themselves of this new method of water supply, but which may probably not be very immediate.

The pumps were made by Roy & Co., of Vevay, and are of the same construction as those which that firm delivered for the waterworks in Zurich and at Penay near Geneva, to the entire satisfaction of those who ordered them. In connection with the water conduit is an air reservoir, by which the motion of the water in the main is regulated.

The reservoir on the heights of Quintzet is dug out of compact clay, which is coated with cement. Its dimensions in the clear are respectively 36 ft., 20 ft., and 300 ft., the contents of which will equal 1,307,537 galls. The surrounding walls measure below 3¼ ft. in thickness, and above 2 ft. only.

With reference to the cast-iron mains, the quantity required measures 12,467 ft. Of these, 7,218 ft. are required for the lifting, and 5,295 ft. for the downward conduit. There were five tenders for contracts to make these, but the one from the firm of L. v. Roll in Solothurn was accepted, under the following special conditions. The pipes for the uplifting are to have a diameter in the clear of 0·40 metre, and those for the downward conduit are to be 0·43 metre in the clear; and the thickness of the pipes are to be relatively in proportion to the pressure, in three series.

To this end the first series (A) for the uplift mains is to be for 3,444 ft., with a thickness of two-thirds of an inch; the second series (B) is for 1,968½ ft. with a thickness of half an inch; and the third series (C) for 1,804½ ft. of 0·45 inches. And for the downward piping, the first series (D), is for 984 ft. with a thickness of 0·43 inch; a second series (E) is for 984 feet and 0·45 inches; and a third series (F) to be 3,281 feet with a thickness of 0·59 inches. This arrangement for the piping is after the same system as that adopted by Mr. Ritter in his waterworks erected at Neufchatel. This system of coupling the pipes together admits of their expansion and contraction, according to the changes of temperature, without risk of separation or of leakage.

Before the pipes are to be laid, every separate pipe is to be tested for pressure, and besides this the contractors are placed under a bond to guarantee their soundness for three years. The delivery is, by contract, to be made in January, February, and March, and must be completed by the 15th of April, 1873. For every day that the contractor may be behind time he has to endure a penalty of £4, and until the expiration of the three years guarantee time the sum of £200 will be kept back from the payments, but such sum is to bear 5 per cent. interest when paid. With respect to the prices paid, a uniform rate was given for both calibres, of 46 francs (£1 16s. 9d.) for the running mètre of the piping, and 300 francs or £25 per ton for the union flanges, delivered free in Freiburg and laid down. Afterwards comes the cost of the erection of the mains, which will amount to £7,000.

The branch piping will be laid on by degrees, and in proportion to the growing demands of the population. By the contract entered into with the town authorities, the whole of the waterworks are to be finished, and to be ready for use, by the 1st of October next, 1873, at the latest; and by same contract the price for the water is never to exceed 50 francs (£2) for each 1,000 litres (220 gallons), delivered within each twenty-four hours, per annum.

7.—The Canal Conduit for Irrigation and Manuring. (Fig. 1.)

Independently of the supply of drinking water, there is another and much more extensive system of canalling for the purposes of irrigation and manuring the fields and meadows on the heights of Neigles, on its north-west side, which will be connected with two points of the undertown gatherings of the sewers and waste waters—the one in the neighbourhood of the projected paper mill, the other near the great suspension bridge. This is to be the undertaking of a branch Company, as before stated. And this second conduit will be as important to the inhabitants of Freiburg and its neighbourhood for sanitary conditions as for economical results, and it speaks forcibly for the vast foresight and the well directed enterprise of the ingenious promoter of these works for the general good. In the plan, fig. 1, the canals may be observed by their dotted lines. These canals will terminate with proportionably large receiving tanks, from which the irrigation and manuring of the neighbourhood are pointed out by the radiating dotted lines.

The raising of this waste water and sewage is brought about by a new method, discovered by Mr. Ritter, and applied here at Freiburg for the first time. This method is based, as is also Capt. Liernur's system, on the application of compressed air, which will be applied in a direct manner on the half liquid matter that will be gathered together in the tanks for the up delivery, and will leave nothing behind. All this will be done without the aid of pumps as hitherto in use elsewhere.

8.—The establishment of Fish-culture, the Bathing establishment, and the Ice-houses of Perolles.

About 1 mile behind the dam, and on the left side of the newly formed lake of Perolles, and at a pleasing and picturesque spot, may be seen the establishment for fish-culture, the bathing establishment, and the ice-houses, &c., all joint undertakings of the one branch Company, as before stated. (Fig. 1.)

The establishment of *fish-culture* was formed for the praiseworthy intention of stocking afresh the waters of the canton for a circuit of about 90 English miles around Freiburg. For this reason then this branch Company, or more properly speaking, Mr. Ritter, caused a concession to be made to him by the Council of Freiburg to farm the fisheries of the canton for fifty years, upon a payment of 100,000 francs (£4,000) as a premium.

The *bathing establishment* is connected with a *swimming school* for the summer, and a *skating school* in the winter. There is also a washing and a bleaching establishment here, besides a hotel, at which, in summer especially, every agreeable and refreshing luxury can be obtained. This spot consequently is likely to become a favourite resort for tourists, and is already one of the most attractive places in the whole neighbourhood for the inhabitants of Freiburg.

In the winter season a temporary residence there will give a fair impression of the severity of an Alpine climate; but notwithstanding such a drawback the place will be much frequented in winter for the purposes of skating.

The *ice-houses* are also immediately in the same neighbourhood, and are built in the steep and shelving sides of the bank on the left side of the Saane. There are already two or three dug out, and it is intended to have ten such ice-houses, each of which is to hold 200 waggon-loads of ice. As it is intended immediately to have a branch railway from the shores of the upper part of this lake, to be connected with the main Freiburg line, for the special purposes of bringing their forest timber in to the saw-mills, and the ice for transportation to all parts, so it may be counted upon that this ice business also has the promise of a flourishing future.

9.—The utilization and farming of the Forests purchased from the Town of Freiburg.

In consideration of the advantages to arise to the town of Freiburg by the creation of this parent Company, as brought about by Mr. Ritter, and more especially as an equivalent for the important benefit of the new water supply, those authorities made over to Mr. Ritter a large forest in the valley of the Saane above the dam on that river. The destiny of this contract goes to prove that it is one of the greatest groundworks of the whole enterprise, and affords a guarantee from the very first that the whole affair will be carried out to the satisfaction of both contracting parties. Against the great costs which the parent Company have been subjected to, through the building of the dam and sluice works, through the turbine arrangements and other waterworks, through the wire-rope transmissive power, and through the other industrial works, it will be mainly recouped through its timber which it purchased from the town, and which the Company will convert into the best possible advantages through the saw-mill, and by the railway carriage manufactory, and through sales of timber at good prices to purchasers from the south of France.

As already stated, this purchased forest comprises no less than 1,446 acres, and was estimated by forest experts at the time to be capable of yielding 6,071,250 cubic feet, and was therefore valued at 164,000 cubic mètres. Until now timber-cutting in this forest has been postponed, and particularly for this reason, because the branch railway line for the transport of the products of the forest and of the saw-mill and the carriage factory were not yet finished. In the meantime the value of the timber has become very much enhanced, and the Company has not only received no damage by the delay in the use and sale of the timber, but on the contrary it will derive considerable advantages, independently of the fact that the timber has taken a considerable growth since the date of the Company's purchase.

The farming of the same by careful culture, cleaning, and fresh planting, was not in the meantime neglected. Besides the timber used from this forest for the erection of the Company's buildings, there have been in this year (1872) no inconsiderable receipts through contracts for the supplying of railway sleepers. But now they have begun in good earnest to bring the timber into the saw-mill, and are fast preparing this business for deliveries to the railway carriage manufactory, and for the use of the other industrial works. Next year, when the saw-mill and large carpenters' shop shall have been connected with the place of delivery for the timber on the Saane by the junction railway (fig. 1) with the trunk line at Freiburg, there will be great gain from the forest, and energy will be exerted to convert the timber into money; inasmuch as sawn timber, in form of boards, is paid for at the rate of 60 francs per cubic mètre, and building timber in beams and posts, at the rate of 45 to 65 frs. (£1 16s. to £2 12s.) by deliveries for export to the south of France; and as the charges against the timber, for cutting, sawing, and for the transport of the sawn timber, will only reach 30 francs, and for building timber 20 frs., so will there remain to the profit of the Company about 30 frs. for every cubic mètre sold—equal to £1 4s. on 36 feet of our English measurements; and at this rate the whole stock of timber at their command would represent 5,000,000 francs (£200,000). Of course this large sum would not come in at once, and the Company will take good care not to use up the gains of their forest in after years, inasmuch that if they did do so, they would destroy their future by thus sapping the life-blood of the whole enterprise. But by the present prudent use of the growing timber, the Company will keep a just balance of the returns from their forest with their other profitable undertakings; and therefore the capital embarked in that forest must prove to be a safe investment.

10.—The laying of the Branch Railway Junction Line.

The timber from the forest of the parent Company will be floated down and across the Saane to the landing-place on the lake of Perolles near the artificial fishery, and will be conveyed from thence to the saw-mill by means of a special railway or tramroad, where it will be worked up into boards, into building and other timber, or in form of some finished product from the large carpentering shop, and from thence be further conveyed to the railway station at Freiburg (fig. 1.) This branch railway line is about two kilomètres long (2,187 yards), and its gradients, from the saw-mills to where the logs are landed from the opposite side of the Saane, do not exceed 14·5 per cent., and from the saw-mill to the Freiburg railway station only 5 per cent. The railway trucks, which will be used for the transport of ice and timber, as well as for the other wares and raw materials, will be driven by a special wire rope transmission, which will have its motive power given to it by that cable that drives the saws.

The construction of this railway is now nearly finished. Beech was used for the sleepers of this line, and these were creosoted by a new plan, from which much good results are expected. According to the last rendering of accounts, the cost of this railway amounts already to £1,437 7s. 1d., and that sum does not cover all its expenses. Added to this, it should be understood that small branch lines or sidings will have to be attached to each of the separate works, and that the promising establishments on the lake of Perolles require such approaches. The incomings from this department of the works will therefore, for some time to come, do no more than balance the expenditure. But when all the buildings are finished, all works in motion, and all the undertakings in full and satisfactory operation, the capital expended on this railway will doubtlessly yield good returns.

By this paper I have tried to describe to my readers, in the concisest possible manner, all the new creations that have taken or are taking place at the old town of Freiburg, and I am convinced that they will acknowledge with me that it is to the great genius and enterprising spirit of the leading director, to whom the special honor is due for the development of this magnificent and very important work. I think, also, that great credit is due to the finance gentlemen, and to the official persons and others who supported him so powerfully in his great undertaking.

On reviewing all these creations, which are the result of free-will, and of mutual trust and confidence, we may be well disposed to agree with the elevating idea of the reporter of the Basel newspaper, who, on writing upon this interesting subject of Mr. Ritter's great works, says—" The people of no city need fear its destiny, when the fruitful intelligence of man is ably supported by willing financiers, and that such intelligence otherwise meets with the acknowledgment and the co-operation of a whole population which can be uninfluenced by the least party spirit, or by any hateful political passion."

Lastly, it may be remarked, that for the completion of the various buildings and works, besides the original capital, it became necessary to issue debentures for one and a half millions of francs (£60,000), bearing interest at 5 per cent.; and that the preferential shares of £20 (500 francs) at present stand at £22 (550 francs), from which it may be determined what good credit and confidence the whole undertaking enjoys in the financial world.

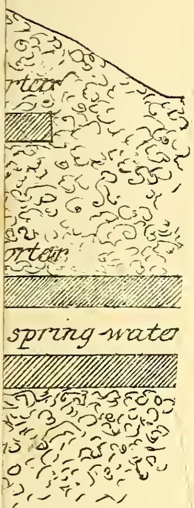
[*Taken from the Augsburg (German) Dingler's Polytechnical Journal, February*, 1873, *No.* 25.]

PLAN
OF
FRIEBURG IN SWITZERLAND.

WITH ITS SURROUNDINGS, ITS WATERWORKS,
AND INDUSTRIAL UNDERTAKINGS,

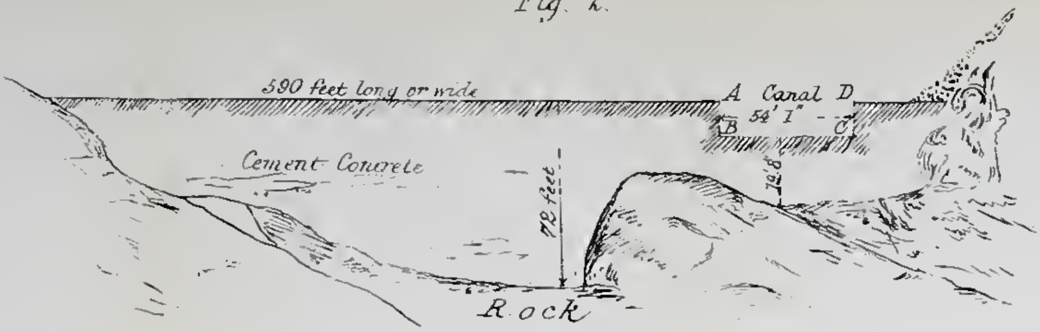
PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, N.S. WALES.

at Freibur



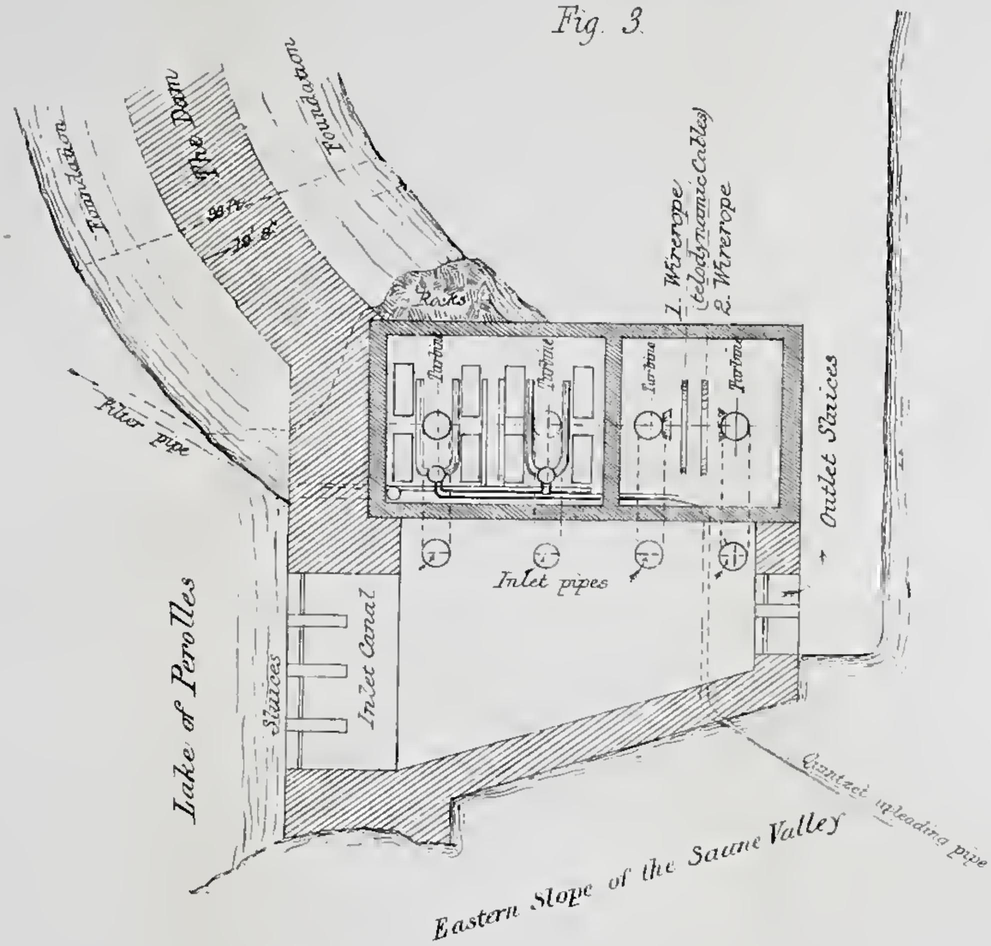
Cross Section of the Dam on the Saane at Freiburg.

Fig. 2.



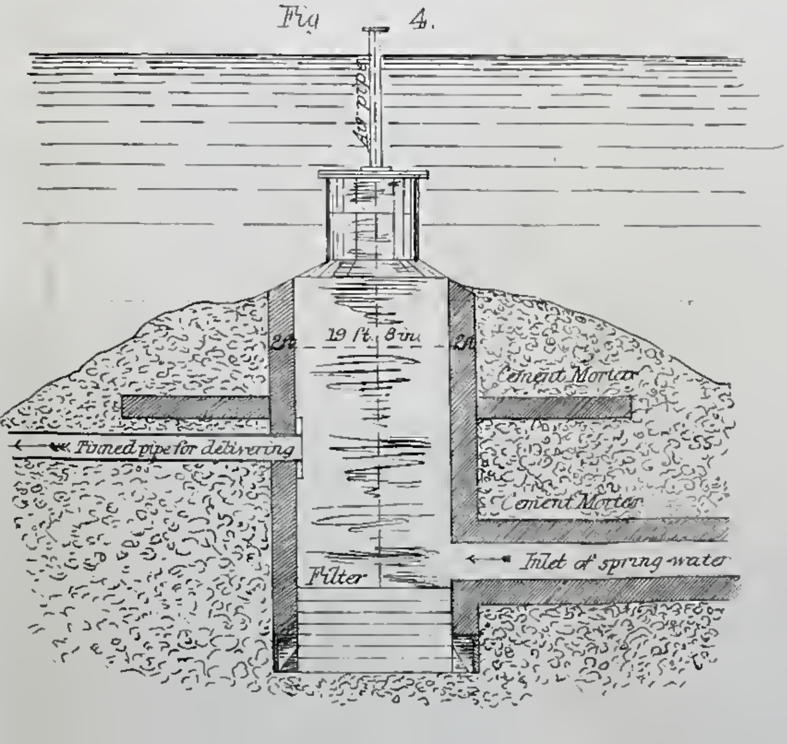
Ground Plan of the Sluice-works, together with Inlet Canal, Turbines, and Pumping-house.

Fig. 3.



Vertical Section of the Filter on the Saane behind the Dam.

Fig. 4.



(3c°12-74)

NICKEL MINERALS FROM NEW CALEDONIA.

By Professor Liversidge, University of Sydney.

[*Read before the Royal Society, 9 December*, 1874.]

These minerals consist of two hydrated silicates of nickel and magnesia, which are found in small veins and fissures traversing the serpentine occurring at Mont D'Or, not far from the town of Noumea, New Caledonia. They are associated with chrome iron,* steatite, and other minerals commonly occurring in serpentine, and are seen disseminated through the loose blocks and boulders of that rock scattered over the surface of the ground.

The chief differences between the two minerals are found in some of their physical properties, for chemically they do not differ so widely—in fact, both forms contain nearly equal proportions of nickel; their other constituents, however, vary considerably.

I have already described one of these forms in a paper read before the Chemical Society of London,† and for it I have proposed the name of *Noumeïte.* The Rev. W. B. Clarke, our esteemed Vice-President, has since suggested the name *Garnierite*, after M. Garnier, a French geologist, who first reported the occurrence of a silicate of nickel and magnesia in New Caledonia.

Although M. Garnier does not appear to have published any detailed analyses of the chemical composition of the mineral, but to have merely described it as a silicate of nickel and magnesia, to him naturally belongs the credit of its discovery.

Therefore acting upon the Rev. W. B. Clarke's suggestion, I propose to substitute the name Garnierite for Noumeïte, which I first proposed for the pale green and adhesive mineral; and for the darker green and somewhat unctuous form I would venture to suggest the name of Noumeïte, formerly given to the first variety.

Garnierite.

Physical characters.

The mineral is amorphous, and in some specimens much fissured. The fissures themselves are filled in with white silica, which thus forms thin plates, crossing one another in every direction, and enclosing the green mineral between them.

The mineral can readily be picked out from between the plates, when a cellular structure like a honeycomb is left.

In colour it is a beautiful pale apple-green to sea-green, particularly brilliant by artificial light.

* The chrome iron in one specimen contained 32·11 per cent. metallic chromium.
† Jour. Chem. Soc., July, 1874.

On immersion in water, the mineral falls to pieces with a sharp crackling sound, splitting up into fragments with conchoidal fracture-surfaces. At the same time it becomes translucent, and acquires a much more vivid tint of green, and for some minutes continues to give off a copious evolution of small air bubbles. It adheres strongly to the tongue, and if allowed to remain attached for a minute or two, it splits up just as when placed in water.

It is not greasy to the touch. Hardness, 2· to 2·5. Sp. gr., 2·27. Streak, pale green. Heated in a closed tube it gives off water and becomes grey. On platinum wire, with borax, it yields the ordinary nickel bead.

Quantitative Analysis.

Determination of the Water.

The finely-powdered mineral was first dried at 100°, and then a weighed quantity of it was heated to redness in a platinum crucible, until it ceased to diminish in weight.

I. ·2302 gram lost ·0120 gram = 5·212 per cent. of H_2O.
II. ·3684 „ „ ·0196 „ = 5·320 „ „

Determination of the Silica.

I. ·5250 gram gave ·2502 of silica = 47·276 per cent. of silica.
II. ·967 „ „ ·4564 „ = 47·197 „ „

Determination of the Iron and Alumina.

I. ·5 gram yielded ·0780 of Fe_2O_3 and Al_2O_3 = 1·560 per cent.
II. ·5 „ „ ·0888 „ „ = 1·776 „

Determination of the Nickel.

By precipitating with freshly prepared ammonium sulphide, igniting, and then again igniting with ammonium carbonate, as recommended by Forbes,—

I. ·5 gram yielded ·1203 = 24·060 per cent. of NiO.
II. ·5 „ „ ·1198 = 23·960 „ „

Determination of Magnesia.

Made in the usual way as pyrophosphate.

I. ·5 gram gave ·2396 pyrophosphate = 21·583 per cent. MgO.
II. ·5 „ „ ·2413 „ = 21·738 „ „

Traces of lime are present.

	I.	II.	Mean.
Water	5·212	5·320	5·266
Silica	47·276	47·197	47·236
NiO	23·960	24·060	24·010
$Al_2O_3 + Fe_2O_3$ ...	1·560	1·776	1·668
CaO	traces	traces	—
MgO...	21·583	21·738	21·660
	99·591	100·091	99·840

The above results do not afford very satisfactory data for a formula, but approximately the mineral may be regarded as $(NiO,MgO)_{10}\ (SiO_2)_8 + 3H_2O$ or $\left.\begin{matrix}Ni\\Mg\end{matrix}\right\}_{10}Si_8O_{26} + 3H_2O$, or, as mineralogically written, $(\dot{Mg}\dot{Ni})_{10}\ddot{Si}_8 + 3\dot{H}$.

I find that by far the major part of the nickel ore as shipped to Sydney, consists of another hydrated silicate of nickel and magnesia; which is at once distinguished from the first by its much darker apple-green colour, and by the differences in its other physical properties for which I have proposed the name of—

Noumeïte.

This mineral also occurs in narrow veins and fissures in the serpentine, but unlike the other it is not so much fissured itself, nor is it permeated by thin plates of silica. It is amorphous, and sometimes occurs in small mammillations—occasionally these mammillations are covered with a layer of minute crystals of quartz, which gives the mineral a beautiful frosted appearance.

In colour it is a full apple-green.

It does not fall to pieces when immersed in water, neither does it adhere to the tongue.

To the touch it is slightly greasy, and may be readily polished by scraping it with the thumb-nail.

Its streak is shiny, and yields a pale green powder.

Hardness, 2·0 to 2·5. Sp. gr., 2·58.

The specific gravity was taken from small fragments, sifted free from all fine powder; these were placed in the specific gravity bottle, weighed, covered with distilled water and allowed to stand for forty-eight hours, with occasional shakings so as to expel all air bubbles; after that time the bottle was filled up to mark, and the operation finished in the ordinary way. Without these precautions it is exceedingly difficult to rid the specimens of all air.

Heated in a closed tube it gives off water and becomes grey. Before the blowpipe it yields the usual nickel reactions.

Like the former variety, it is dissolved by hydrochloric acid, with the liberation of non-gelatinous silica.

As will be seen from the accompanying results, the chemical composition is by no means very uniform in different specimens:—

	I.	II.	III.
Silica	58·763	47·90	49·54
Alumina and iron ox. ...	·509	3·00	1·60
Nickel oxide	undet.	24·00	26·80
Magnesia	„	12·51	13·86
Lime	traces	traces	traces
Water	8·038	12·73	undet.
		100·14	

The iron is present in the form of protoxide.

After trial of all the methods of determining nickel in the presence of alumina, iron, silica, and magnesia, it was found that the best results were obtained by the process of first removing the iron and alumina, converting the nickel into acetate, and rapidly passing sulphuretted hydrogen to saturation. After standing for a few hours the supernatant liquid would be perfectly clear and bright; if left standing many hours it was often found that a portion of the nickel had again entered into solution—at once detected by the blackening of the filtrate on proceeding to wash the precipitate in the usual way with sulphuretted hydrogen water.

On comparing the physical properties and the chemical compositions of these two varieties of nickel and magnesium silicate with those of such minerals as Alipite, Pimelite, Genthite, and others, it will at once be seen that they bear certain resemblances to one another; but they do not possess sufficient properties in common to group them under one name.

From the following table comparing the different hydrated nickel and magnesium silicates, it will be seen that although Alipite, Garnierite, and Rewdanskite all are amorphous, have a green colour, a hardness of about 2 to 2·5, a low sp. gr. from 1·4 to 2·77, and adhere to the tongue, yet Garnierite differs widely from Alipite in containing far less magnesia, and from Rewdanskite also in having only 1·66 iron and alumina oxides against some 15·40 per cent. entering into the composition of the latter.

Then the three, Pimelite, Noumeïte, and Genthite, besides possessing several other physical characteristics in common, are naturally still further bound together by the property which they present of being more or less unctuous or greasy to the touch; yet in spite of these common properties they differ considerably in chemical composition.

Noumeïte only contains from ·509 to 3·00 per cent. iron and aluminium oxides; Pimelite, on the contrary, contains from 9·58 to 25·73 per cent.; and Genthite from 0·24 to 10·65; and moreover, they differ much in their proportions of magnesia, water, and other constituents.

Table for Comparison.

Alipite.	*Garnierite. New Mineral, α.*	*Rewdanskite.*	*Pimelite.*	*Noumeite. New Mineral, β.*	*Genthite.*
Amorphous.	Amorphous.	Amorphous, laminated lumps.	Massive, earthy.	Amorphous, veins and incrustations.	Amorphous, incrustations.
Hardness = 2·5.	Hardness = 2·0—2·5	H. = Falls to powder on pressure.	Hardness = 2·5.	Hardness = 2·5.	H. = 3—4.
Sp. gr. = 1·44—1·46.	Sp. gr. = 2·27.	Sp. gr. = 2·77.	Sp. gr. = 2·23—2·76.	Sp. gr. = 2·58.	G. = 2·409.
Colour, apple-green.	Apple-green.	Colour, dirty greyish green.	Apple-green, light.	Apple-green, dark.	Pale apple-green or yellowish.
Adheres to tongue.	Adheres to tongue.	Adheres to tongue.	Does not adhere to tongue.	Does not adhere to tongue.	
Not unctuous.	Fracture conchoidal.		Greasy to touch.	Somewhat greasy to touch.	Lustre resinous.
	Falls to pieces in water.			Does not fall to pieces in water.	Falls to pieces in water.

Alipite		Garnierite	Rewdanskite		Pimelite		Noumeite	Genthite	
SiO_2 …………	54·63	47·236	$Si O_2$ ……	32·10	35·00	— 35·80	47·90	35·36	— 33·60
$Al_2O_3 + Fe_2O_3$	1·43	1·668	Al_2O_3 + Fe	15·40	9·58	25·73	3·00	0·24	10·65
NiO …………	32·66	24·010	NiO ………	18·33	15·63	2·78	24·00	30·64	30·40
MgO…………	5·89	21·660	NigO ……	11·50	1·25	14·66	12·51	14·60	3·55
CaO…………	0·16	traces	H_2O ………	9·50	0·42	—	traces	0·26	4·09
H_2O …………	5·23	5·266	Sand………	13·00	38·12	21·03	12·73	19·09	17·10
	100·00	99·840		99·83	100·00	100·00	100·14	100·19	99·30
(Schmidt, Pogg. lxi, 388.)			Hermann J. pr. Chem. c. 100, 1868.		(Klaproth.)	(Van Baer.)		(Genth.) Texas Pa.	(Hunt.) Michipicoten, Canada.

Subsequently it may be found necessary to lessen the number of species of such minerals; future research may show, and I think most probably will show, that one or more of the species may be done away with; but until specimens of all of them have been more closely examined it will prove convenient to retain the above distinctive names for them, even if it be only to show their localities thereby.

They all appear to be found in serpentine rocks, and, as far as can be gathered, in serpentine containing a certain proportion of diffused oxide of nickel; thus the New Caledonian serpentine contains 1·0 nickel oxide, or 0·78 per cent. metallic nickel; it is however, by no means an uncommon thing for small quantities of nickel to be found in the serpentines of Cornwall and Devonshire, of Banffshire, of Saxony, Canada, and other places.

According to all accounts, the above minerals, Garnierite and Noumeïte, appear to occur in large quantities; the ore as delivered in Sydney contains from about 4 per cent. to 10 or 15 per cent. of metallic nickel, while the major part contains about 6 per cent to 7 per cent.

The minerals are evidently the decomposition products of other compounds, and it is not at all improbable that the arsenides and sulphides of nickel may be found in depth.

I am inclined to think that Garnierite is probably a modified form of Noumeïte: it looks as if it had been more exposed to weathering influences or to the action of a higher temperature; it is also more closely associated with silica, *e.g.*, it contains plates of silica or quartz between its fissures.

IRON ORE AND COAL DEPOSITS AT WALLERAWANG, NEW SOUTH WALES.

By Professor Liversidge, University of Sydney.

[*Read before the Royal Society, 9th December*, 1874.]

Many are probably well aware that there are large deposits of iron ores and extensive beds of coal in the neighbourhood of Wallerawang; but comparatively few, perhaps, are in possession of any very definite information concerning them. I therefore beg to lay before you the substance of some notes, taken during a brief visit which I made in the early part of August last, and the results of my subsequent examination of the samples of the ores and coals which I then collected.

I much regret that I cannot afford any general and comprehensive account of the geology of the district; and that it is only in my power to speak definitely upon the actual deposits of iron ore, coal, and the closely associated limestone. For, owing to an unfortunate accident which I met with to my foot, within a few days after my arrival at Wallerawang, I was entirely prevented from making any detailed investigation of the various strata and deposits other than of those which follow.

I very much regret too that I had to relinquish the idea of working out the geological section of the district; but as Mr. Chas. Wilkinson, the Geological Surveyor recently appointed by the Government, is now engaged making a survey of the district, we shall probably soon be in possession of a complete report upon the whole of the coal measures and iron deposits of this area, and in a much fuller and more detailed form than I could possibly have hoped to have worked it out in the time at my disposal, consisting as it does merely of short intervals of leisure.

Wallerawang is distant from Sydney some 105 miles, on the western line of railway.

The township and station of that name is situated on a "drift" composed of pebbles disseminated through a soft argillaceous cement or clay. The enclosed pebbles consist principally of rolled fragments of quartz, jasper, flinty-slate, argillaceous sandstone, and other substances. On the whole, this drift bears a very close resemblance to the diamond-bearing drift of Bingera and other places; and, like the diamond drift, it contains nodules of conglomerate, composed of rounded and sub-angular fragments of white and coloured quartz, and various other minerals, agglutinated together into a compact mass by a ferruginous cement.

It also contains a small quantity of gold, but apparently not in sufficient quantity to pay for working at the present time.

This drift can be traced for some distance—as far, I am informed, at Bathurst. Good sections of it are seen at the Wallerawang Railway Station, and along the Mudgee and other roads near the town, where several small cuttings show its structure very well.

The deposits of iron ore at present opened out are situated some six miles from Wallerawang, and near the junction of the coal measures with the Upper Silurian or Devonian beds, which there crop out to the surface. These deposits contain two varieties of iron ore, viz.—magnetite or the magnetic oxide of iron, and brown hematite or goethite—the hydrated oxide; then in addition to these there are deposits of the so called "clay band," which are interstratified with the coal measures. These clay bands are not what are usully known as clay iron ores in England. They are brown hematites, var. limonite, while the English clay iron ores are impure carbonates of iron, which seldom contain much more than 30 per cent. metallic iron, against some 50 per cent. contained by the hematites.

A highly ferruginous variety of garnet accompanies the veins of magnetite; this garnet is very rich in iron and it will probably be found advantageous to smelt it with the other ores, not only on account of the large percentage of metal which it contains, but also on account of the increased fluidity which it would impart to the slag.

Iron Ore Deposits.

1. *Magnetite.*—The vein of magnetic iron ore runs apparently N.E. by S.W. This can only be stated approximately, for, owing to the action exercised by it on the needle, the compass was found to be perfectly useless in the vicinity of the lode.

The ore is scattered over the ground in blocks and nodules along its outcrop; but at a little depth it is in a solid and compact body, merely broken across here and there into large masses by joints and fissures.

In one part the vein has a width of thirteen (13) feet; but at another spot, where a trench was cut across, it was there found to be not less than 24 feet in width.

Two shafts have been sunk on this vein—one to a depth of 10 and the other to a depth of 23 feet. At these depths the quality of the ore is about the same as that at the surface.

Certain portions of the vein are evidently richer than others.

At present the average yield of metallic iron from the vein, as a whole, is not rich for a magnetite, which, when perfectly pure, contains 72·41 per cent. of iron, and under ordinary circumstances about 70 per cent., whereas the Wallerawang vein yields only 40·89 per cent. (*See analysis appended.*) Although this is a poor magnetite, it must not be regarded as a poor ore of iron.

This average was obtained by taking samples from different parts, across the whole width of the trench cut across the vein, and then crushing them all up together. As I have before mentioned, picked portions yield a much larger percentage.

On the whole, taking all the circumstances into consideration, we may come to the conclusion that the true capabilities of the deposit of magnetite have not yet been fully tested or proved.

The vein stuff or gangue accompanying the magnetic iron ore is silicious. In some parts of the lode this appears to be replaced by the ferruginous garnet rock.

On analysis this ore yielded the following results:—

Silica and insoluble matter ...	18·70 per cent.
Metallic iron	40·89 „
Phosphorus	Traces.
Sulphur	Traces.

Both the phosphorus and the sulphur are present in such minute quantities that the ore may be regarded as virtually free from them; and these are the only really deleterious substances present, for although there is too large a quantity of silica and gangue present in this superficial portion of the vein to permit of malleable iron being made from it by a direct process, it is extremely well adapted for reduction in the blast furnace.

2. *Garnet.*—The garnet occurs both crystallized, in the form of the rhombic dodecahedron, and in the massive state. The crystals are, as is usually the case, very uniform in size; they are nearly all of them either about $\frac{1}{8}$ or $\frac{1}{4}$ of an inch in diameter.

The faces of the crystals are smooth, free from pits and irregularities, and bounded by sharp and well-defined edges. The colour is brown without any red shade.

Portions of the massive garnet and aggregations of crystals are hard and compact, whilst in other parts they are more or less disintegrated and friable.

The average percentage of metallic iron is 21·05—an amount not much less than that contained by many commonly smelted ores.

3. *Brown Hematite.*—The general direction of the outcrops of this deposit is not so regular as that of the magnetic lode, and it will probably be found that other veins run into it, but for a large portion of its course it runs approximately N.E. by S.W.

Although the back of the lode does not absolutely come to the surface along its entire course, yet there is a great probability of all the different outcrops being connected beneath the surface—in which case the total length of the deposit, as far as it has been at present traced, cannot be much less than one mile.

Along this line of outcrop the ore is seen scattered all over the surface in great blocks and nodules, either completely exposed or but partially embedded, and over a width of from 12 to 18 feet in parts, to as much as even 50 or 60 feet in another.

The thickness of the deposit below the surface has not yet been fully ascertained; but a shaft has been put down in the lode itself to a depth of 43 feet, and at the bottom a level was driven which proved it to be of the same quality through a thickness of 18 or 20 feet. There are no decided appearances of the boundaries of the deposit having been cut, except on the N.E. side, so that it may eventually prove to exceed the above-mentioned thickness.

As far as can be seen from the outcrops and other indications, the deposit has nearly every appearance of being a true vein or lode, in which case of course its depth may be regarded as practically unlimited, for there is nothing on record which shows that the bottom of any true vein has ever been reached in mining operations. Veins have often been regarded as worked out altogether when reduced perhaps to a mere thread, but, on continuing to sink, such veins have always been found to open out again. One cannot of course say that this will always be found to be the case, but it always has been the case, when sufficient perseverance has been used in following the traces of the vein downwards.

However, although there are strong indications of this deposit of brown hematite being a true lode, it has not yet been conclusively proved to be one; subsequent workings may show it to be an irregular deposit such as those of the Forest of Dean and other places in England.

As the shaft already put down is sunk through the deposit itself, the stuff raised and heaped up at the shaft mouth affords a very fair sample of the average quality of the ore.

The ore is composed of nodules of mammillated and botryoidal goethite, possessing a fibrous structure something like that of wood, mixed with massive and friable brown hematite, together with a little pipeclay. On descending the shaft, its walls, on all sides and from top to bottom, are seen to be composed of the same ore, only, of course, from not having been disturbed it is much more compact Near and at the bottom, a "horse" of pipeclay comes in, but one of no great size.

A sample of the ore taken from the heap at the shaft's mouth, just as it was raised, and without having undergone any dressing process, yielded on analysis the following results :—

Analysis of loose brown Hematite.

Water, hygroscopic	2·74
,, combined	9·70
Silica and insoluble matter	25·33
*Sesquioxide of iron	54·23
Phosphorus	·27
Sulphur...	·12
†Undetermined	7·61
	100·00

If for any special purpose a richer and purer ore be required, the nodules could be readily separated from the loose ore before it is sent to the surface. As shown by the following analysis, these nodules are much richer, and contain on an average 51·52 per cent. metallic iron.

Analysis of Goethite and massive Hematite.

Water, hygroscopic	1·28
,, combined	12·04
Silica and insoluble matter	12·19
‡Sesquioxide of iron	73·60
Phosphorus	·12
Sulphur...	·06
†Undetermined	·71
	100·00

As will be seen from the above analysis, this brown hematite contains but very small proportions of phosphorus and sulphur, and far less than the well known Northamptonshire brown iron ore.

Probably it will be found feasible and economical to work much of this deposit as a quarry in stopes, on account of its great width, and because it is favourably situated on a hill side. By this method expensive shafts and galleries can be dispensed with.

* Equivalent to 37·84 per cent. metallic iron.

† Consisting principally of manganese, alumina, lime, and magnesia.

‡ Equivalent to 51·52 per cent. metallic iron.

4. *Clay bands.*—As I have already mentioned, the English clay iron ores, or "clay bands" as they are generally termed, are impure carbonates of iron, containing a large quantity of argillaceous or clayey matter. In Scotland an ore of this kind occurs, containing a large quantity of carbonaceous matter as well, and is known as the "black band," and like the English "clay bands" it is found interstratified with the coal measures. The percentage of carbonaceous substance varies from 10 to 15 per cent., and in some cases rises to even 30 per cent. The presence of this is a great advantage, for they contain sufficient to effect their roasting, previous to reduction, without the addition of any extra fuel.

This so called "clay band" appears to be more of a brown hematite, of the kind known as limonite.

I was enabled to examine four seams of this ore. They are interstratified with the coal measures, and, in common with them, at this part they are approximately horizontal, having only a slight dip of not more than about 2° to the N.E.; their outcrops are seen jutting out in the gullies and creeks on both the E. and W. sides of the Dividing Range.

The lower of the four seams is perhaps the least pure and valuable of them all; but the other three are of very good quality and of great value, as shown by the analysis.

Analysis of clay band iron ores.—Clay band No. 1.

Water, hygroscopic	1·28
,, combined	3·54
Silica and insoluble matter	4·60
*Sesquioxide of iron	80·00
Phosphorus	·49
Sulphur	·11
†Undetermined	9·98
	100·00

Clay band No. 2 contains 53·31 per cent. metallic iron.

Clay band No. 3 contains 49·28 per cent. metallic iron.

It is highly probable, from the unusual richness of clay band No. 1, and from the small quantity of combined water which it contains, that it has been subjected to a bush fire, and answers, therefore, more or less, to roasted ore. A sample of this ore, taken from an unexposed portion of the seam, would most likely yield about 50 per cent. metallic iron, in place of 56 per cent.

As is usually the case with such deposits, the thickness varies somewhat; in some places they are from 8 to 9 inches thick, and

* Equivalent to 56 per cent. metallic iron.

† Consisting principally of manganese, alumina, lime, and magnesia.

then a little farther on they widen out to a thickness of even 18 inches. The average thickness of the two lower seams may be taken at about 10 inches each, and the upper seam (No. 3) at 11 or 12. These dimensions are estimated from the outcrops of the seams, and are of course only approximate, for as they have not yet been opened out or cut across in any way, no clean sections are exposed, and consequently no minute measurements could be taken.

It is at once apparent from the analysis that they are all three richer than the ordinary English clay band ore, and that the amounts of phosphorus and sulphur, for all ordinary purposes, are unimportant.

Coal.

The coal measures in this district contain several very valuable and thick beds of coal. The three principal ones which I had the opportunity of closely examining have respectively the following thicknesses of coal irrespective of any partings:—

The lowest seam, which I will call No. 1, has a thickness of 17 feet 6 inches; the next seam, No. 2, is 6 feet 6 inches; and the one above this, No. 3, is 4 feet 6 inches.

There are other seams present, but as they are thinner they are of minor importance, and in the face of the above thick seams they are not likely to be touched for some years.

Seam No. 1.—The outcrop of this bed is seen in the banks on a creek known by the name of Coal Creek, on the western side of the Dividing Range.

A trial shaft sunk through it has proved it to be 17 feet 6 inches in thickness, divided by a parting of fire-clay some 8 inches thick.

The parting of fire-clay shows the numerous remains and impressions of coal measure plants—principally thin rootlets in this case—embedded in the original soil in which they grew. At this period of the history of the coal bed there must have been a change in the conditions throughout the area over which this parting extends; the circumstances had become unsuitable for the continuance of the growth of luxuriant vegetation which previously covered it. This unfavourable change may have been brought about by a variety of causes. It was most probably due to a gradual depression of the area beneath the surface of the water, which period of depression extended sufficiently long to allow of the deposition and accumulation of the eight inches of finely divided mud and silt which was the original form of the fire-clay. It is generally regarded that coal has been derived from the decay of terrestrial plants which flourished in marshy places, and that the majority of them consisted neither of true land nor of true aquatic plants, but of such as go to form the peat mosses, the mango and other swamps of the present day; hence a considerable depression of the area would be inimical to such growths. After this process of depression had gone on for a certain time, then the area was again slowly upheaved and the remaining eight or nine feet of coal was accumulated.

The quality of the coal is very good: it is hard and compact, and would therefore be well adapted for certain metallurgical processes, especially for use in the blast furnace, where it would have to sustain a great weight, and under circumstances where ordinary tender bituminous coal would have to be previously coked.

It possesses a sp. gr. of 1·333.

Analysis of 17 ft. 6 in. seam of coal.

Moisture		... 1·51	
Volatile hydrocarbons		... 33·24	
Coke	Fixed carbon	... 55·74	= 65·24 coke.
	Ash, white	... 9·50	
		99·99	

It is very free from sulphur.

This bed, in common with the others, is nearly horizontal; it has, however, a dip of about 2° to the N.E.

Seam No. 2.—An outcrop of this bed is seen in Coal Gully, and an exploratory level has been driven into it to a distance of about 60 feet.

At the outcrop, where cut by the level, it is seen to be about 6 feet 10 inches in thickness, with a 2-inch parting of fire-clay, which, however, is gradually pinched out as the level proceeds inwards, and finally disappears altogether on the face.

The roof is a hard and compact sandstone. Throughout their entire thickness the coal measures consist of alternate beds of fire-clay or shale—the original soil on which the coal vegetation grew—coal and sandstone succeeded by shale, then coal again, and so on. Occasionally the order may be slightly altered, but in the main the series is continued throughout in that way.

In quality the coal is almost identical with the former one, but as is shown by the analysis, it contains rather more combustible matter and less ash. Like the former, it is very free from sulphur.

Coal from Seam No. 2. (6 *ft.* 6 *in.*)

Moisture		... 1·95	
Volatile hydrocarbons		... 27·25	
Coke	Fixed carbon	... 61·86	= 70·80 coke.
	Ash, white	... 8·94	
		100·00	

It possesses a sp. gr. of 1·398.

Seam No. 3.—This seam has a thickness of 4 feet 9 inches, with a 3-inch parting, leaving 4 feet 6 inches of coal.

It is rather a brighter and more tender coal than the others, and will probably be found well adapted for household purposes.

It occurs at a height of about 76 feet above the seam No. 2 or 6 ft. 6 in. bed, while that in turn is about 118 feet above the seam No. 1 or 17 ft. 6 in. bed.

Clay band No. 1 is situated some 12 feet above this No. 3 seam or 4 ft. 6 in. bed, and the other two clay bands are a little higher still.

One of the seams of coal crops out on the Mudgee Road about 2½ miles distant, but as I did not take the levels this requires confirmation. This seam is worked, apparently on no large scale, by levels driven in from the road side.

Limestone.

Limestone.—Between the iron ore deposits and the coal seam outcrops there is seen an outcrop of limestone abutting against Devonian or Upper Silurian slates. Both the slates and the limestone are here standing at a high angle. The limestone does not show the dip so distinctly as the slates, for the lines of bedding have been almost completely obliterated, but the dip appears to be about 75° to the eastward, and the strike nearly N. & S.

At the junction of the two the limestone has evidently undergone much disturbance and is much brecciated, and includes within it fragments of the slate. Some of the included slate contains small crystals of iron pyrites disseminated through it.

In colour the limestone is of a bluish-grey or slate-colour, much veined with white calcite. The slate-coloured portions break with a slight crystalline appearance, but the calcite veins show the rhombohedral cleavage of that mineral on a large scale.

Its extension can be traced for a long distance to the north.

Not far from the small quarry which has been opened out in this limestone on Brunt's Creek, perhaps a hundred yards or so to the right hand after crossing over the creek, there is the opening to a fissure in the limestone. On the surface, just level with the ground, there is a small somewhat circular opening, surrounded and overgrown by grass and bushes—so much overgrown that it is almost completely hidden. This is probably the entrance to a cave in the limestone, for they usually afford no more indication of their presence than such a grass-grown aperture. The opening is only wide enough to allow of a man lowering himself some four or five feet, but from that point a narrow fissure can be seen to descend for some depth. Diligent search might prove that there are other openings, and the cave to be of some extent—and there is of course a very fair chance of its being found to contain animal remains; so that I hope Mr.

Winter, of Wallerawang, who pointed it out to me, will be induced to follow his discovery up. The narrowness of the opening is not at all unfavourable to the supposition that the cave may eventually prove to be an extensive one, for very few limestone caves present large and well-marked entrances.

Caves in limestone have usually had their origin in fissures, through which water flows or at one time flowed; the water at first slowly percolating through them, and then as the fissure gradually became larger and larger the volume of water likewise increased until the fissure became converted into a true underground river or watercourse. Even in cases where no water flows through them at the present day it can plainly be seen that such was the case once, as exemplified in the caves or "swallow-holes" of Yorkshire, the Katavothra of the Morea, South Australia, and many other parts.

These caves are eaten out of the limestone by the solvent power which water charged with carbonic acid possesses. Ordinary water free from carbonic acid would be quite incapable of dissolving out the limestone, but all natural waters contain more or less of that gas, derived by the rain from the atmosphere as it falls and from the decaying vegetable matter which it meets with in its passage through the soil.

All limestone caves usually retain more or less completely their original form of fissures, expanded, perhaps, in parts into vast caves and chambers of immense proportions, but again contracting a little further on into a mere crack or tunnel.

Comparatively large rivers are received by such caves, which then continue their course under ground, in some cases suddenly appearing to the light of day again, but in others making their way beneath the surface right out to sea. Certain of the South Australian creeks are thus discharged.

I do not refer to this subject of caves in limestone so much on account of the supposed one at Wallerawang—for it may quite likely be proved to be merely the beginning of one—as to draw attention to the occurrence of such apertures in limestone districts, in order that they may be properly investigated.

In conclusion, I think I may safely say that this portion of the district of Wallerawang seems to be destined to be one of the greatest and most flourishing portions of the Colony. Here, within a comparatively small circle of some four miles diameter, there are extensive and rich deposits of iron ores, coal, and abundance of limestone. At present nothing beyond exploratory work has been done with them; but as the Wallerawang Iron and Coal Company has taken up large selections of the lands for the purpose of erecting iron works, there is a prospect that, in a short time, an attempt may be made to utilize some of this great wealth.

The whole of the district along the western line, near to and beyond Hartley, is one of exceeding interest to the geologist from a purely scientific point of view, quite apart from the importance and actual intrinsic value of the various mineral deposits which it contains.

It is a source of great gratification to all who take any interest in these matters that, at last, the resources of this and other portions of New South Wales stand a fair chance of being thoroughly and properly examined, now that the first step towards having a geological survey of the country has been taken by the Government,—a step which may be regarded as an earnest of something to follow on a more comprehensive and extended basis; for of course it is utterly impossible for any one geologist, however great his attainments, to make single-handed a finished survey of a country like this.

No one will deny that money spent upon such an object is spent in one of the best possible ways, whether it be purely for the extension of scientific knowledge or merely for the exploration and development of the mineral wealth of the Colony. Perhaps the truest wisdom is to keep both ends in view: the extension of science would make but comparatively little progress without the aid of wealth, and wealth, at the present day, cannot be attained without calling in the aid of science—they are mutually dependent, and on that account we cannot afford to neglect either of them.

The exploration and development of the mineral wealth of a country should always be kept a long way in advance of the work of realizing and converting such stores into money.

When we consider the great repositories of iron ores which have been already examined in New South Wales, and that we hear of discoveries of others, perhaps equally extensive, there appears to be no reason why New South Wales, with proper care and management, should not very soon make not only all the iron required for its own consumption, but also supply other countries which are not so lavishly endowed.

SOME OF THE RESULTS OF THE OBSERVATION OF THE TRANSIT OF VENUS IN NEW SOUTH WALES.

By H. C. Russell, Esq., B.A., Government Astronomer.

[*Read before the Royal Society,* 11 *January,* 1875.]

Never before in the world's history did morning dawn on so many waiting astronomers as it did on the 9th of December, 1874. They were all anxiously looking for an answer to the old question, "*to be, or not to be,*" and certainly none could have expected a finer day than that which dawned on the observers in New South Wales; from all stations, in return for the morning clock signals, came the welcome intelligence that the morning gave promise of a splendid day, and after hearty good wishes had been given and received, we all turned to the final touches which were necessary to complete our arrangements, and when these were done, waited, not without an involuntary feeling, which I will not call excitement, for that by common consent had been banished, but rather an overpowering sense of responsibility which every true worshipper of science must feel, when he knows that the answer to half a century's questionings are depending upon him; not lessened because he feels he is the observed of all observers, determined to do his best in the noble cause of science; and perhaps under all, not without a faint hope that his name and his work will appear ages hence in the records of science, and be criticized under that blaze of knowledge which the united efforts of the world's science shall produce.

And here it may not be out of place to introduce a few words about the selection of the New South Wales stations. For ingress there was little choice, for, the sun being in the zenith of a place near Rockhampton, the parallax was almost nothing everywhere. At egress, however, our circumstances would be much improved in this respect, and the south-eastern point of New South Wales would be one of the best points of observation in Australia. In addition to this, there were two other conditions to be borne in mind in making the selection, viz., weather, and telegraphic convenience for determining longitude.

I had for two years previously caused special meteorological observations to be taken at various places during the month of December. These made it evident that the observers should not all be stationed at Eden, but be divided between the coast and the mountains, and indicated Woodford as about the most promising station for clear and steady atmosphere. Bathurst and Goulburn were alike in chance of clear weather; but Goulburn was the better station geographically, and was therefore selected. Eden weather reports were not encouraging; but as the advantage of position was so much in its favour, it was decided to make it the fourth station, and there the Rev. W. Scott, formerly Astronomer for New South Wales, proceeded, with Messrs. W. J. Mac Donnell and J. S. Watkins, observers; and Mr. Sharkey, photographer to the Government Printing Office, as photographer, and one carpenter, with observatory, tents, instruments, and all needful appliances. A description of these must, for want of time, be reserved for the published reports. Suffice it to say, the telescope used by Mr. Scott was a $7\frac{1}{4}$-inch equatorial, of 10 feet 4 inches focus; by Mr. MacDonnell, a $4\frac{1}{4}$-inch Cooke equatorial; and by Mr. Watkins, a $3\frac{1}{2}$-inch equatorial; they had also means of taking 220 photographs. Captain Hixson, President of the Marine Board, Captain Onslow, M.P., and Professor Liversidge, made the observing party at Goulburn, with Mr. Tornaghi, photographer, and a carpenter. Observatory, tents, instruments, &c., were similar to those at Eden, but the telescopes were rather smaller, having 6 inches, $3\frac{3}{4}$, and $3\frac{1}{4}$ inches object glasses, with means of taking 220 photographs. To Woodford, which is the country house of A. Fairfax, Esq., who kindly gave us every assistance in his power, even to lending his own valuable $4\frac{1}{2}$-inch Schroeder telescope, P. F. Adams, Esq., Surveyor General, proceeded, with Messrs. Hirst, Vessey, and Du Faur, also Mr. Bischoff (photographer), and two carpenters. The instruments here were somewhat different from those at the other stations. Knowing, as I did, from experiments made on the spot with the telescope, how favourable the atmosphere was for photography, I determined to send the Dallemeyer photo-heliograph with Janssen apparatus there, and with it one observing telescope; plates, chemicals, &c., were provided for 220 whole photos of the Sun, and thirty Janssen plates, with sixty photos on each. The observatory was similar to that used at Goulburn; and Mr. Adams, who gave me very great assistance, provided transit instrument, another observing telescope, &c., besides two ordinary tents and two round ones for observatories.

At Sydney the observations rested wholly on the Observatory staff, and the instruments used were $11\frac{1}{2}$-inch refractor, 12 feet 6 inch focus, $4\frac{3}{4}$-inch refractor, 81 inches focus, and a 10-inch unsilvered glass reflector, by Browning and With.

I cannot leave this part of my subject without expressing the high praise which I feel to be due to all who assisted me in these observations. With a zeal worthy of the occasion, they devoted themselves to a course of previous practice at the Observatory which involved an amount of self-denial and perseverance worthy of all praise. From the officers also of the Railway and Telegraph Departments we received very great assistance; indeed, every one seemed to make common cause for once with the astronomers, and did all in their power for the Transit of Venus.

Previous to starting, all the observatories and instruments were set up in Sydney, and each party went to work in their own observatory; this we found to be of great service in pointing out weak points, which required either more practice or the instrument maker to set right.

For practice in observing, we had two artificial transits, one similar to that designed by the Astronomer Royal, the other constructed in the Colony. With this a great deal of practice was obtained, which was useful in training for observation. At the same time all were warned that there was no certainty about the black drop phenomena.

We come now to the day's work, and take first the weather at each station.

At Eden the morning was fine and very promising, but about 11 a.m. clouds began to come in from the sea, with a fresh sea breeze, and the observers began to anticipate a disappointment. Fortunately up to the time of ingress the clouds had not interfered with the observations; but from that time forward the sun was more or less obscured, and at one period wholly so for 80 minutes, so that few photographs could be obtained, and the sun was entirely obscured some time before egress.

At Goulburn the morning was fine, with light westerly wind and a few drifting clouds; during the afternoon the wind increased to half a gale, and the clouds were more numerous, but not sufficient to interfere with observation.

At Woodford the morning was fine, with a dry hot wind (westerly), which increased as the day wore on; during the afternoon a few clouds passed over and interrupted the photographic work for a short time, but at ingress and egress the weather was splendid for observation.

At Sydney the early morning was beautifully clear until 5·30 a.m., when a heavy bank of fog came in from the sea, and obscured the sun for three hours; but we still expected a fine day, and were not disappointed, for by 9 a.m. we had a clear bright sky and light north-easterly wind, which increased to a fresh sea breeze during the afternoon. The state of the atmosphere also was favourable for observation until the transit was over, except a few moments of bad definition; but had we been one hour later, I do not think observations of egress would have been worth anything, for clouds were rapidly forming in the S.W., and, though thin, they spread very quickly over the sky.

Next, to the times of observation; and for the purpose of convenient comparison I have arranged all in a tabular form, and approximately corrected them for difference of position, and put all into Sydney time. I confess when I saw the gradual phenomena of the transit myself I did not expect such a satisfactory agreement between the times of observation as some of the results show; and if $4\frac{1}{4}$ seconds could be taken (as it was by astronomers at home) as a fair estimate of the probable uncertainty of observed time at one station, when a definite phenomonon like the breaking of the black drop had to be observed, I think we, under our no black drop difficulties, may congratulate ourselves that the differences are in most cases so small.

Only three out of thirteen observers took the time of first contact, and they were evidently a few seconds, probably about ten, late. Such, at least, was my own impression at the time, for Venus had made something more than contact: it was a small notch in the sun's limb.

My time is	11h. 55m. 23·00s.
Mr. Lenehan	11h. 55m. 36·34s.
Woodford—Mr. Vessey	11h. 55m. 12·96s.

These times show a very satisfactory agreement, especially when the difficulty of seeing external contacts is taken into account, and the fact that in 10 seconds of time Venus would only encroach about half a second of arc on the sun's limb, a quantity not easily seen, and equal to one-thousandth part of an inch seen at a distance of 34 feet. For second contact I think there can be no doubt that different phases of the phenomenon were taken by observers according to the different effects produced by the expected black drop, which up to that time had a very tangible existence for all of us; and as it is very important that the exact phenomenon taken by each observer as internal contact should be on record, I will here quote from the reports, beginning at Eden.

Mr. Scott took the time when "he saw the partial obscuration of the sun's limb by the planet's atmosphere gradually diminishing until it disappeared altogether at 12h. 23m. 7·90s." which I take to mean the completion of the sun's outline, the same phase which, as will be presently seen, I and others took for complete ingress.

Mr. MacDonnell took the time when "the light seemed to be going in and out several times, and prevented any accurate determination of complete ingress as 12h. 24m. 34·70s.," but he is convinced he was 15s. late, making the time 12h. 24m. 19·70s.

At Woodford Mr. Vessey took the time when Venus appeared to touch the sun's limb, or when the two limbs were tangential. (See diagram 5.) Time, 12h. 23m. 45·07s.

My own report of this phase is as follows, and it will be observed that the first time given is 4 minutes before contact.

At 12h. 20m. indications of distortion or bad definition of the limbs in contact appeared, like a mass of black wool laid over the place, rendering it impossible to see distinctly, and making the cusps very hazy. I thought the drop was going to form, and watched very closely for it and for apparent contact, but I found it extremely difficult to make up my mind about the latter, and saw nothing of the former. 12h. 20m. 5s. was noted as a very unsatisfactory apparent contact. The cusps after this appeared to clear up, or improve in definition (the telescope had not been altered), and as they approached each other the sharpness was very remarkable, but the motion so gradual that I could not determine to a fraction of a second when they actually formed the line of light which I saw complete, and took for the moment of internal contact, but the instant I was sure I made the record on the chronograph, and keeping my eye steadily upon it saw it had in fifteen seconds become an unmistakeable band of sunlight.

Mr. Lenehan says at time of ingress there was an indistinct shading between the supposed edge of the planet and the sun, which for some ten or fifteen seconds before the time I quote later, kept me in a state of uncertainty as to the true time of actual ingress; the shading did not break abruptly, but seemed to melt away in such a manner as to leave a doubt in my mind of the exact time the planet passed the edge of the sun, but I distinctly saw a clear band of light at 12h. 24m. 48·34s.

Mr. Savage says:—"The definition at this point being so very bad between the limits of the sun and planet, and the edges at contact so very dark as to defy accuracy, as the planet advanced on the sun a little way this shading still connected the planet with the sun's edge; but that portion of it nearest to the planet showed indications of fading away gradually, until at length it disappeared altogether without any sudden break whatever, and at 12h. 23m. 43·9s. a streak of light became visible between the planet and the sun's limb."

Dr. Wright noted 12h. 24m. 30s., but was quite sure this was late, probably 16s., making 12h. 24m. 14s., having lost true contact looking for the black drop. These times are:—

h.	m.	s.
12	24	7·90
12	24	19·70
12	23	45·07
12	23	59·00
12	24	48·34
12	23	43·93

But I think it is evident that only Mr. Scott, Mr. Vessey, and myself have taken exactly the same phase here, and the mean of the three results is 12h. 23m. 57·32s.; the differences amongst all the times are too great to give a satisfactory mean; but if taken it is 12h. 24m. 7·32s. Perhaps some of the differences may be attributed to differences of temperament.

For the third and really most important phase we had all fortunately learned to disbelieve *in black drops*, and during the photographic work had time to think and talk over what had been seen at ingress, and we went to our telescopes much better prepared for the work before us; still the difficulties were by no means gone, and the motion of the planet was so exceedingly slow that a few seconds variation is, I think, a necessity.

It was unfortunately cloudy at Eden, but the Goulburn observations now make up for it.

Captain Hixson saw internal contact ...	3h. 54m. 30·01s.
Professor Liversidge ,, ...	3h. 54m. 22·37s.
Mr. Tornaghi ,, ...	3h. 54m. 27·70s.
At Woodford, Mr. Vessey says at	3h. 54m. 45·41s.

"The circles of sun and planet tangential, and the ring of light about its own thickness outside the limb of the sun."

My own time for this phase is ... ... 3h. 54m. 39·66s.

After a period of bad definition my report says:—"The limbs recovered their perfect definition, and were clearly and steadily separated by a line of light which at 3h. 54m. 26·3s. could not have been more than half a second of arc in thickness, and then the same marvellous definition continuing just when it was wanted; the line gradually contracted to a scarcely visible thread, and the limbs made contact. There was no sudden break, nothing but the perfectly gradual motion of the one disc over the other, both beautifully defined, and I saw one overtake the other."

Mr. Lenehan says:—"The first apparent contact was at 3h. 54m. 21·61s., a little jumping; afterwards, saw a band or faint and narrow streak of light between the limbs of planet and sun, which clearly showed me that the time above given was too soon. I then waited until I was absolutely certain contact was complete, at ... 3h. 54m. 46·61s.

"I feel confident this time is from 7s. to 10s. after true time."

Mr. Wright makes time of contact ...	3h. 54m. 39·59s.
Mr. Allerding makes time of contract ...	3h. 54m. 35·00s.

Now at Goulburn at this time the wind had become very strong, and produced a tremulous motion which would no doubt account for the times being a little early, for it would not be possible under those conditions to see a very fine thread of light, and we know that such was seen by the observers who agree best.

Taking the mean of all we get 3h. 54m. 35·79s., and the mean of the last five is 3h. 54m. 41·25s. as below :—

3h. 54m. 30·01s.		
22·37s.		
27·70s.		
45·41s.	......	45·41s.
39·66s.	......	39·66s.
46·61s.	......	46·61s.
39·59s.	......	39·59s.
35·00s.	......	35·00s.
286·35s.	......	5)206·27s.
3h. 54m. 35·79s.	......	41·25s.

For last contact we have only three observations which do not accord very well. At Woodford Mr. Vessey took time as ... ... 4h. 23m. 58·40s.

This observation appeared to be correct to a small fraction of a second ; the indentation on sun's limb gradually contracted in width till within 13 seconds of time given, and it then seemed to contract longitudinally till it became a small notch like a boiling indentation. This was seen steadily diminishing till it suddenly flashed out, and the limb of the sun became perfect.

My own observation makes this ... ... 4h. 24m. 27·00s.
At this time the last sign of the planet on the sun's disc was seen as the faintest possible mark, which then disappeared, definition being then for the time very good, and the observation quite satisfactory.

Mr. Lenehan saw last and final contact at 4h. 23m. 49·61s.
the edge of the planet being then lost in the edge of the sun.

My own observation of this phase does not seem to be supported, but the larger aperture of the telescope I used, viz., 6 inches, and the steady motion of the telescope by clockwork, probably explain the difference ; and this view is strengthened by reference to Mr. Ellery's observation in Melbourne, working with similar advantages. He saw the planet until 4h. 24m. 28s., within 1 second of my time.

The predicted times of these phenomena given in the English Nautical Almanac are very far from the observed times. The times given are :—

	h. m. s.	m. s.
1st contact.		
From Nautical Almanac ...	11 52 18	
Observed	11 55 23	= 3 5 after N.A.
2nd contact.		
From Nautical Almanac ...	12 21 12	
Observed	12 23 59	= 2 47 after N.A.
3rd contact.		
From Nautical Almanac ...	3 55 54	
Observed	3 54 40	= 1 14 before N.A.
4th contact.		
From Nautical Almanac ...	4 25 12	
Observed	4 24 27	= 0 45 before N.A.

	h. m. s.
The whole predicted interval, 1 to 4 contacts ...	4 33 54
The whole observed interval, 1 to 4 contacts ...	4 29 4

That is, 3m. 50s. less than predicted.

The whole predicted interval, 2 to 3 contacts ...	3 34 42
The whole observed interval, 2 to 3 contacts ...	3 30 41

That is, 4m. 1s. less than predicted.

This is a different result from what would have been expected on comparing intervals, for it is generally assumed that external contacts cannot be observed within 10 or 15 seconds, and the above seems to show that the interval between external contacts was comparatively longer than the internal interval. If we take the mean of the times observed for 2nd and 3rd contacts we get—

	h.	m.	s.
2nd	12	23	57·32
3rd	3	54	39·92
Difference	3	30	42·60
Whole predicted interval	3	34	42·00
		3	59·40

—which makes the interval 2 to 3 even greater than my own observations, and seems to point to an error in the whole predicted interval as well as in the times of the phenomena.

Turning now to the physical phenomena observed, there are several of them very interesting and important that will repay a little consideration, and first in regard to the *black drop* so called, that is, a ligament or connection that it was asserted formed when the limb of Venus was on that of the sun. The explanation of the black drop given by Mr. Stone, now Astronomer Royal at the Cape of Good Hope, seemed so thoroughly satisfactory that I fully accepted it, and I think in common with nearly all observers, expected to see the planet distorted, and drawn into a pear shape as it left the sun's edge; and then instantly become surrounded with a band of sun-light: a phenomena the exact time of which could have been easily determined, but instead of this a set of wholly unexpected phenomena presented themselves.

As the planet encroached on the sun, the cusps remained perfectly sharp until near the time of contact of the limbs, when a curious hazy appearance became developed, and rendered it impossible, in spite of all efforts, to see exactly what was going on. Most, if not all the observers, thought the *drop* was forming, but close attention only revealed a gradual disappearance of the haze until the sun's and planet's limbs were left perfectly clear and sharply defined with a thread of sunlight between them.

Rev. W. Scott says, in reference to this point:—" I continued to watch the planet for more than three minutes, and saw the partial obscuration of the sun's limb by the planet's atmosphere gradually diminishing until it disappeared altogether."

Mr. MacDonnell says:—" As Venus proceeded, the shadowy envelope disappeared, except between the planet and the sun's limb, where it seemed to fill up the space between them with faint rings concentric with the planet's edge. There was no distinct rupture of this appearance, the light seeming to go in and out several times." Professor Liversidge says,—" A faint, hazy, gray filament like a streak of smoke was momentarily observed between the edge of the planet and the sun; it was very obscure and ill-defined."

My own report for ingress is as follows:—At 12h. 20m. indications of distortion or bad definition of the limbs in contact appeared, like a mass of black wool laid over the place (see diagram 1), rendering it impossible to see distinctly, and making the cusps very hazy. I thought the drop was going to form, and watched very closely for it, and for apparent contact, but I found it extremely difficult to make up my mind about the latter, and saw nothing of the former. 12h. 20m. 51s. was noted as a very unsatisfactory *apparent contact*. The cusps after this appeared to clear up, or improve in definition, and as they approached each other the sharpness was very remarkable.

At egress, after the limbs had made contact, a curious phenomenon presented itself similar to that remarked at ingress, the two limbs at the point of contact seemed to get confused, or badly defined, whether from atmospheric causes near us or some peculiarity about Venus I am unable to say, but it seemed to disturb the definition of the planet at the point of contact in a most remarkable way.

Mr. Lenehan says—" At the time of ingress there was an indistinct shading between the supposed edge of the planet and the sun, which for some seconds kept me in a state of uncertainty as to the true time of actual ingress, the shading did not break abruptly, but seemed to melt away in such a manner as to leave a doubt in my mind of the exact time the planet passed the edge of the sun."

Mr. Savage says:—"The definition at this point being so bad between the limbs of the sun and planet, it is quite likely the time given by me might be about ten seconds late; the edges at contact then became very dark. As the planet advanced on the sun's disc a little way, this shading still connected the planet and the sun's edge; but that portion of it nearest to the planet showed indications of fading away gradually until at length it disappeared altogether withont any sudden break."

It is evident that what we have here described is a phenomenon very different from that which is known as the *black drop*, for here the uncertainty lasts much longer, and does not occur when the limbs are apparently separated, but when they are in fact as well as appearance in contact and slightly overlapping; and while this phenomenon is clearly made out to have lasted about four minutes, Mr. Stone, Astronomer-Royal at the Cape of Good Hope, and the best authority on this subject, estimated that the black drop would only last eighteen seconds.

I cannot see any possible explanation of this appearance except that which is afforded by assuming a considerable atmosphere around Venus, and there are some other facts noted on evidence too strong to overlook, which certainly seem opposed to this supposition.

If, however, for the present we assume that Venus has an atmosphere something like that of the Earth—say, of 40 miles extent—it would, on the day of transit, have subtended an angle of only one-third of a second of arc, or much too small a quantity to be recognized, unless as a bright line on a dark back-ground, or by its effects in diffusing light, and it is in this way that it helps us with an explanation of this hazy phenomenon. Such a faint line of atmosphere, so long as it crossed the cusps at a considerable angle, would have no appreciable effect on the cusps, and they would remain as they were seen, quite sharp; but when the limbs of the sun and planet were near the point of contact the cusps would become very much attenuated and for a considerable extent quite within the power of our assumed atmosphere, and the effect would be manifest, not so much from the diameter of the light cut off, as from the length of the cusps so affected; and it is remarkable, as bearing upon this view, that the cusps were apparently seen through the haziness; and on myself and other observers the impression produced was similar to a want of focal adjustment; and the gradual clearing up, melting away, &c., which we have heard described is exactly what would be seen when a fine line of light was emerging from behind an atmosphere; and that the planet should look perfectly sharp immediately the sun-light appeared is also quite in accordance with the supposition we have made. On the other hand, Mr. Vessey, who had a good telescope in the best atmosphere, certainly saw nothing of this haziness at egress, and did not see much of it at ingress.

Of the drop phenomena which we all expected to see we have two particularly interesting accounts, which I will quote. The first is that by Mr. Hirst. Only saying that he was thoroughly acquainted with the phenomenon as described by Mr. Stone and others, and that he had some previous practice with the artificial transit, though the work which was specially his, and of which he had made himself master, was the management of the photo-heliograph during the taking of the Janssen pictures.

"Attached to the tube of the heliograph was a finder, consisting of a *single* lens, $1\frac{1}{2}$ inch aperture and about 4 feet focal length. This was originally arranged by the maker so as to throw the sun's image on to a piece of parchment fixed at its focus; but in order to adapt it to circumstances which required that one end of the heliograph should be in the photographer's dark room, the lens was inserted in the end of a brass tube, an eye-piece being provided in the shape of a Huyghenian combination, giving a power of about fifty diameters. The chromatic and spherical aberration of the single lens was in a great measure compensated by its extreme focal length, so that fair definition could be obtained of the edge of the sun, and the existence of even minute solar spots made plainly visible."

"To diminish the light in the finder I used a thick piece of orange-coloured glass, which gave an agreeable image of the sun. This was placed outside the eye-lens of the eye-piece."

"I had prepared and placed a plate in the Janssen apparatus, when, on taking my usual glance at the finder, I observed the disc of Venus appearing, as it were, rather more than one-third her own diameter within the sun, and connected with the limb by a narrow line intensely black, with an ill-defined edge. The annexed diagram No. 2 represents the appearance as faithfully as I can recollect; this was about five seconds before No. 5 Janssen plate was begun. I had not time for more than a glance, for I wished to procure a photograph of what I supposed to be the black drop, so universally observed by astronomers, more than a century ago, at the last transit. On getting the plate through, however, it showed nothing of what I had so distinctly observed a few seconds before."

"Referring to the finder, Venus appeared well inside the sun, but apparently *nearer* the limb than she seemed before. The drop was gone. I thought at the time that it might have broken before the exposure of the plate, and I determined to keep a sharp look out for its formation at egress. Soon afterwards Mr. Vessey came in and reported that the 4½-inch had shown no drop at all."

"Towards egress I referred constantly to the finder, that I might be ready with a plate directly the drop became visible. When Janssen plate No. 9 was in its place, and upon adjusting with the finder, I observed no black drop, the planet appearing so far within the sun's disc that I did not think it necessary to hurry in order to catch the drop, and exposed the No. 9 plate, meaning to get another in time. After taking out the plate, which probably occupied twenty seconds, I went to the finder, and to my astonishment saw that the drop had formed, appearing about as long as one-third the diameter of the planet; I hurried on the next plate as much as possible, but a delay unfortunately of a couple of minutes occurred before it was ready; on development it showed Venus a perfectly circular disc touching the sun's limb."

"I regret exceedingly that my eye was not at the finder during the precise moment of the formation of the drop, but my duties at the Janssen eye-piece prevented me from staying there more than a few seconds at a time."

"Referring to what I saw through the finder, I am convinced that my observations, short though they were, have not deceived me. I was thoroughly prepared, and on the look-out for the phenomenon at egress, and I have not the slightest doubt that any one using similar optical instruments would undoubtedly have observed what I did."

If we turn now to No. 5 Janssen plate, and seek a photograph of the drop, we find that photography, at least when aided by Mr. Dallmeyer's beautiful lenses, refuses to acknowledge any such phenomenon; on this plate there are sixty photographs without a sign of the drop, but all showing a distinct band of sunlight round the planet. It will be remembered that while this was going on in the photoheliograph observatory, Mr. Vessey was in the next place observing the phenomena of ingress with a very fine 4½-inch equatorial, by Schroëder. With this instrument a splendid view of the ingress was obtained, and he noted internal contact at 12h. 23m. 45·07s. No. 5 Janssen plate was begun at 12h. 25m. 35·47s.; and Mr. Hirst saw the drop at 12h. 25m. 30s., or some time after egress had taken place, and it appeared to him equal to one-third the diameter of the planet. Now we know it was only 1m. 45s. after observed ingress, and the photographs prove that the planet was only one-twenty-second part of its diameter within the sun's limb.

Of course there is the possibility that the drop might have broken between the time when Mr. Hirst saw it and the time he began to turn the handle for the Janssen pictures; but he passed from one to the other as quickly as possible; and even if it did break, we have the facts clearly made out that the drop was seen 1m. 45s. after ingress, and that although it appeared nearly equal to the semi-diameter of the planet in length, yet it was certainly not more than one-twenty-second part of the diameter, as shown by the photograph.

On comparing the time of No. 9 Janssen plate, after allowing 20s. lost in taking it out, with Mr. Vessey's time of contact, it appears that the drop at egress was seen 1m. 45s. before contact, or was in fact about the same length as at ingress.

Mr. Allerding, chronometer maker, of Hunter-street, also saw the drop most distinctly, and watched it through the various phases till it broke. He was using at the time a very good 3½-inch achromatic telescope, but to avoid sun-light and heat he had reduced the aperture to 2 inches, and with this small opening he obtained very satisfactory definition of the sun and planet. Unlike Mr. Hirst, who observed in the beautiful atmosphere of the mountains, Mr. Allerding observed from the back yard of his house in Hunter-street, which is surrounded by houses. In a report of his observations, which he has furnished to me, he says—"At the internal contact at ingress I saw a drop which formed into a cone, and when this had nearly disappeared it seemed to stretch out to a fine thread (see diagrams), to which Venus seemed to be attached. The thread appeared hard and definite, without any hazy margin, and I estimated its length at one-third the diameter of the planet. It then instantaneously disappeared at 12h. 24m. 44s., and Venus appeared already well detached from the sun's limb. Had I not waited for the disappearance of the fine line, I would have made inner contact at least thirty seconds sooner." Now, in this case we have no Janssen photographs to show how long the drop was, but we have other observations taken in Sydney which prove that the drop seen by Mr. Allerding was equal in length only to the space moved over by the planet in forty-five seconds; that is, 1·7 seconds of arc from the sun's limb—or two-and-a-half times the length Mr. Stone estimates it to be. I cannot see any satisfactory explanation of these facts. What cause could magnify the length of the drop, even if it had a real existence, from one-twentieth to one-third the diameter of the planet, I am at a loss to conceive; or why, of three telescopes of small aperture two should exhibit the drop and the other not I am also at a loss to explain, and must for the present at least leave it in uncertainty.

There are however several observations recorded of a kindred phenomenon that I should like to place on record. At ingress I saw nothing of it, but at egress I saw it distinctly; and the cause is, I think, easily traced. But to take, first, the observations at ingress.

Messrs. Bellfield and Park, who were observing at Armidale with a $4\frac{1}{2}$-inch Cook telescope, that I examined and know to be a good one, have sent me a valuable report, and drawings of what they saw, and state that—" While Venus was advancing at ingress to about one-fourth her own diameter upon the sun, a faint tremulous shading was seen between the limb of the sun and the planet (both bodies being very sharp in outline), which disappeared so gradually that it could not be said to have been obliterated at any particular instant."

Mr. Bolding, P.M., Raymond Terrace, observed with a 3-inch telescope, and has forwarded to me a very complete report of the whole transit, and remarks :—" At the moment I expected a complete circle (*i.e.*, internal contact) came the apparent pause, instantly followed by a kind of indistinctness which resolved itself into the form of a figure 8. The thing seemed to be holding up the planet, so to say. The line seemed blacker than the central spot; then the light came very distinctly between the planet and the line; then the indistinctness between the sun's limb and the line cleared up, and for a short time the line was clearly seen midway between the planet and the sun's limb. The sun was very hot at the time and the definition bad."

At ingress I saw nothing of this phenomenon, but at egress I did, and my report is as follows :—" At times there were moments of bad definition evidently caused by the clouds then forming in the west. During one of these, at 3h. 53m. 54s., when Venus was less than 2 seconds of arc from the sun's limb, the limb of the planet nearest the sun's edge seemed to be in a state of vibration, as if portions of its blackness were jumping over to the margin of the sun with an appearance similar to sketch (diagram 3), which represents one vibration only. This lasted only a few seconds—the vibrations being estimated at 6 or 7 per second. After this the limbs recovered their perfect definition, and were clearly and steadily separated by a fine line of light."

Mr. Lenehan saw it, and says—" The first apparent contact was at 3h. 54m. 22s., a little jumping. I afterwards saw a band or faint and narrow streak of light between the limbs of planet and sun."

Messrs. Belfield and Park saw the same appearance at egress as at ingress. Mr. Bolding saw nothing of it at egress, which he attributed to the increased steadiness of the atmosphere.

I think there can be no doubt that this appearance was caused by temporary unsteadiness in the atmosphere, which by producing rapid vibrations or apparent motions in the limbs under examination, caused them momentarily to overlap, and so cut off the sunlight and produce the black appearance, an effect which all who have been in the habit of observing stars in powerful telescopes will at once understand.

We come now to the last point that I propose to speak of to-night. The information I have collected about it is in some respects very puzzling, but I have no doubt still more light on the physical character of Venus will yet come out of the light of the halo that we have observed. That it was a very brilliant and beautiful object will be made abundantly evident by the accounts which follow, and that it would be possible to write an interesting paper on this subject alone, long enough for one meeting, I am quite sure; two present opportunities are however, not open to me; and I crave your patience while I endeavour to give as concise and faithful account of it as I can in the short space that remains.

And beginning as before, with Eden. Mr. Scott, who was using a 7¼-inch equatorial, of very fine definition, and of which the aperture was reduced to two inches, says:—"For some minutes before internal contact I could see clearly the whole of the planet's outline; in fact it presented exactly such an appearance as might have been expected from a planet possessing an atmosphere." Mr. MacDonnell says:—"At the time of apparent bisection a shadowy nebulous ring seemed to envelop Venus; on the preceding side it was of lighter tint than the planet, but was decidedly perceptible, and appeared to be about one quarter or one-fifth of the diameter of the planet in width. When ingress was about two-thirds completed the whole outline of the planet was distinctly visible in the telescope, the shadowy envelope surrounding it very plainly."

At Goulburn, Captain Onslow first saw the halo at 12h. 17m. 5s. A bright light was seen at the lower point of intersection of the circles, and in a few seconds a similar one at the upper point, and at 12h. 19m. 5s. an apparent circle was formed by the planet.

Professor Liversidge says, when the planet was about one-third of its diameter from third contact:—"It then appeared spheroidal, and not as a disc merely; it appeared illuminated on the under side in the direction of the sun's diameter, or on the side of the planet towards the sun's centre, and this illumination shaded off on each side of the planet, but at the portion nearest the sun's limb it appeared quite black and opaque. This globular appearance was retained until the planet had passed off the sun's limb to the extent of about one-sixth of its diameter.

"After internal contact the planet looked somewhat as if it were pushing that portion of the sun's limb before it, for the solar limb appeared to be raised up into two processes, one on each side. At the time I thought it might perhaps be due to an atmosphere surrounding Venus, or to an optical illusion, but since I have heard that other observers saw the illuminated edge of Venus beyond and outside the sun, I am inclined to think it was that which I saw. However, I did not see a circle, but merely two portions or cusps brightly illuminated, but not as bright as the sun."

At Woodford Mr. Vessey saw so much of the halo that it would not be possible to reproduce it all without extracting greater part of a long report. The halo was first seen at 12h. 7m., but not outside the sun ; it appeared to extend inwards from the cusps, resembling a gradually fading line of dots.

"At 12h. 15m. 30s. the following limb of Venus was distinctly defined by a faint line of light which was rather brighter on the northern side ; 3 minutes later, ring of light increasing in beauty, silvery, decidedly brighter on north side of middle, perhaps ½ a second in thickness."

"After complete ingress the definition was magnificent, and atmospheric ring on, *i.e.*, within the disc of the planet, similar to what I first saw at 12h. 7m., but broader, and gradually shading off towards the centre, to be traced all round, giving Venus an appearance of relief like an oblate spheroid, or rather a flattened dome standing away from the sun, the radius of the flattened part being about half that of the planet."

At egress Mr. Vessey saw the ring of light directly contact was made, and steadily as the planet proceeded—" at first like a small arch upon the sun's limb. At 4h. 2m. 35s. the ring of light on planet appeared as a sharply defined line, and less than one second of arc in thickness ; 6 minutes later, disc of Venus still continued undoubtedly a globe, and appearing slightly reddish or copper-coloured like the moon in an eclipse, the sky adjoining intensely black, with the suspicion of a greenish tinge contrasting with the colour on the planet."

Mr. Du Faur, observing at Woodford, with a 3-inch telescope, the eyeglass of which (after being smoked) was cracked by the sun, and therefore in a very unsatisfactory state for observations, still saw the whole of the planet when it was about two-thirds on the sun ; and during the interval between internal contacts, had frequent opportunities of observing Venus with the 4½-inch telescope after it had been carefully focused on the sun spots, and saw Venus as sharply defined as it would be possible to represent it on paper, and perfectly black.

"At ingress I did not myself see the halo until 12h. 16m. 0s. It appeared only round that part of the planet not on the sun. It was very remarkable and beautiful, like a fringe of green light, through which the faintest tinge of red could be seen. It was densest near the planet, and seemed to shade off to nothing, with a diameter estimated at one second of arc. It did not appear solid like the disc of the sun, but like light in a dense vapour. As ingress proceeded the halo became more conspicuous, but I did not observe any want of uniformity in its diameter. At egress I saw nothing of the halo until 3h. 57m. 7s., nearly 2½ minutes after internal contact. The halo was exactly similar to that seen at ingress, and the whole of the planet at this time appeared to me intensely black. The halo remained steadily visible for some time, but gradually faded, owing to a great increase in brightness of the atmosphere about the sun; and at 4h. 6m. 52s. I first observed that the surface of Venus was not black as it had been, but appeared as if covered with thin, hazy clouds, somewhat thicker on the planet's northern hemisphere. At this time, the haze having much increased, I lost sight of the halo, and at 4h. 12m. changed the coloured glass for one of lighter tint, and at once saw the halo again, and for the first time noticed that it was irregular in diameter; it seemed considerably broader at the *north pole of the planet*, and shaded off more rapidly towards B than C (see sketch, diagram 4), but I found it impossible to look at the sun steadily with this light glass, and again changed it for a darker one, when all the halo, except the part at the north pole, disappeared. This white patch continued visible until within one minute of last contact, and I feel confident I should have seen it some time *after last contact* but for the rapidly increasing atmospheric haze, which had also much increased on the planet, making it difficult to see where it ended and the sky began.

Mr. Lenehan says:—" At 4h. 16m. 21s. the planet appeared with the outer edge apparent, and I noticed a spot of light on the preceding side. It did not appear to me as anything more than a spot."

Messrs. Belfield and Park saw the following limb of planet at ingress distinctly illuminated, and when the planet was wholly on the sun the body of the planet appeared intensely bluish black in centre, becoming gorgeous deep blue towards the circumference; at egress the illumination of the planet's limb was again seen, but only on the north side. Mr. Bolding only saw the halo at egress, and though visible all round that part of the planet off the sun was most marked on the north side.

It will be seen that we have here three distinct phenomena. A broad ring of light ouside the planet, a bright ring of light round that part of the planet projected on the sky, and band of light or shading round the inner edge of the planet, or over its surface. No spots, however, were seen on the planet, except the very remarkable part of the halo at the north pole.

The cause of the halo seen by Messrs. Lenehan and MacDonnell has not been satisfactorily made out, though it has been repeatedly seen during transits of Mercury. It seems exceedingly improbable that Venus has an atmosphere of such extent as would be required to produce such a halo or ring of light, and if the atmosphere had any density at all similar to that of the earth, the light would be bent inwards, and become too diffuse to be seen long before it reached us. It appears, however, certain that it is one of those curious phenomena seen only by some observers under special conditions. During the transit of Mercury in 1868 it was watched very closely by a number of observers in England, who were seeking information that might be useful for the transit of Venus; and out of fourteen observers, including some of the best in England, only three make any mention of exterior halo. Mr. Stone thought it simply an effect of contrast.

Probably some of the light seen on the planet this time had a similar origin, for no observer has, so far, reported seeing both. A part of it, however, must, I think, be attributed to haze in our own atmosphere, which, being very luminous owing to moisture then forming, would appear projected on the black planet, and the contrast would very likely give it a shaded appearance from the edge towards the centre. To me the blackness of the planet, both at ingress and egress, was very intense, until the haze in our atmosphere became thick and gave the surface of the planet a cloudy look, so that I could scarcely see where the planet ended and the sky began; and it may be that the same cause produced what Professor Liversidge and others saw; but at Woodford the air was too clear for such an explanation. The red tint seen by Professor Liversidge is explained by his having used a red glass shade.

The increase or thickening of the halo seen at the north pole of the planet, and which to several of the observers seemed to encroach on the planet, is a most interesting feature.

The remaining ring of light or halo is, however, the most interesting physical feature observed, though at first sight it would be attributed to an atmosphere similar to that of the earth. I think a little consideration will show that it cannot have such an origin. It is spoken of by all the observers as very brilliant, by some as white compared with the sun; and its actinic power was so great that, although its diameter was certainly less than one second of arc, and would only appear as a fine line in the photo-heliograph less than one five-hundredth part of an inch in diameter, it yet had power to affect the chemicals in something less than the two hundred and fiftieth part of a second; in other words it was quite as powerful, if not more so, than direct sunlight, and we have a number of photographs in which it appears.

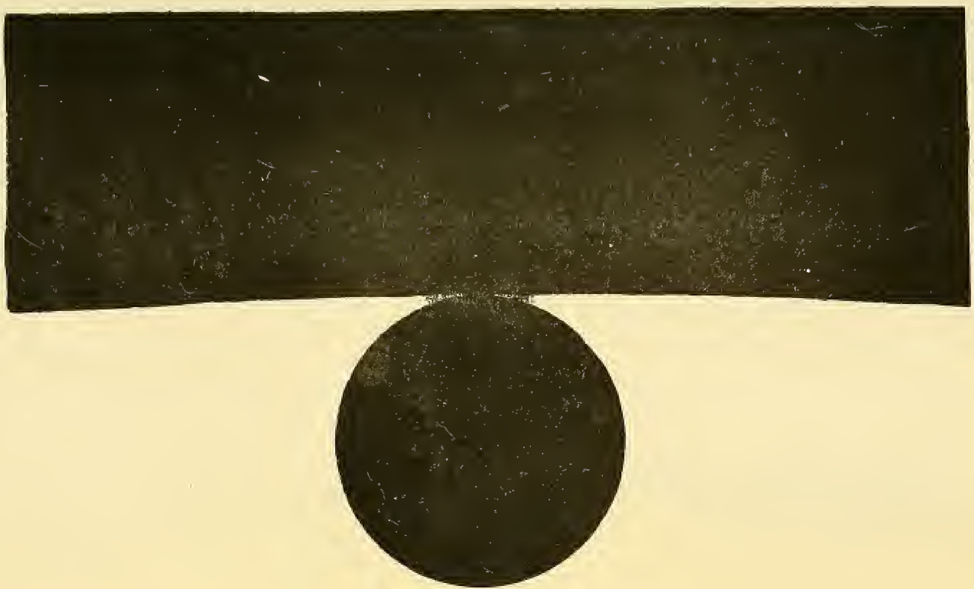
This great brilliance, of course, explains why it was not seen about the planet while on the sun's disc. It was evidently not to be distinguished from the sunlight. In the clear atmosphere at Woodford it was seen as soon as the cusp parted at egress, and it will be exceedingly interesting next time Venus is lost in the sunlight to try if, under favourable conditions, the halo can be seen. Quite sure I am that, if the air had been clearer at egress, I should have seen the planet with the halo round it projected upon the sky; as it was I saw part of the halo until

Venus was nearly all off the sun's disc, and one minute before last contact. Taking all these facts into consideration, I cannot see any cause sufficient to account for a ring of light such as that described as seen about the planet, but an envelope of some perfectly translucent substance, such as water. And it is to be hoped that those who used the spectroscope in the northern hemisphere were fortunate enough to get the spectrum of the halo, and settle this question.

Of the valuable series of photographs which we have obtained little can yet be said. They must all be subject to careful measurement with a micrometer made for the purpose, before the results can be pronounced. And probably twelve or eighteen months will elapse before all the results of the world can be combined so as to settle the question of the sun's distance.

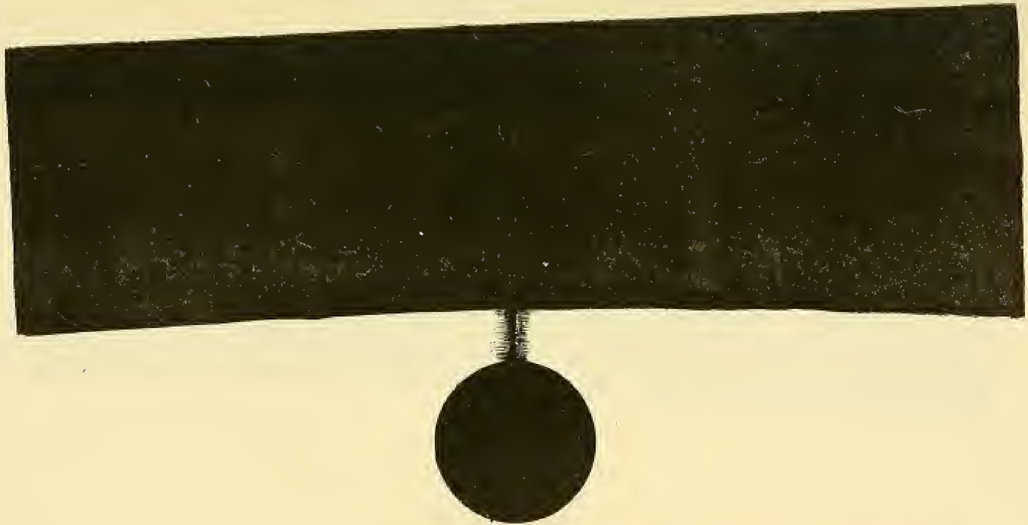
Some, however, of our Janssen plates give results which are obvious enough without measurement; one of these is the extreme sharpness of all the cusps, even at the very time when the black drop should have had full power over them. Of the sixteen plates, having about sixty photos on each—the first plate shows a small notch in the sun's limb; Nos. 2 and 4, planet still further in; No. 5 is the one taken when the black drop was seen; No. 6 shows the planet wholly within at ingress; 7, 8, and 9, the same at egress; No. 9½ shows the planet on the sun's limb, with halo; No. 10, planet partly off sun, with some pictures of the thickening of the ring of light about the pole of the planet; Nos. 11 to 16 plates, at egress; No. 17 was passing through when last contact was observed, and shows the faintest notch in the sun's limb till within a few seconds of observed last contact. The value of these plates is very great; photography is not biased by preconceived theories of what it should see, and is therefore a witness upon questions of physical aspect whose evidence no one may gainsay.

[Five diagrams.]



Enlarged sketch of Haziness after contact at Egress

Mr RUSSELL



NARROW BLACK BAND CONNECTING PLANET AND SUN

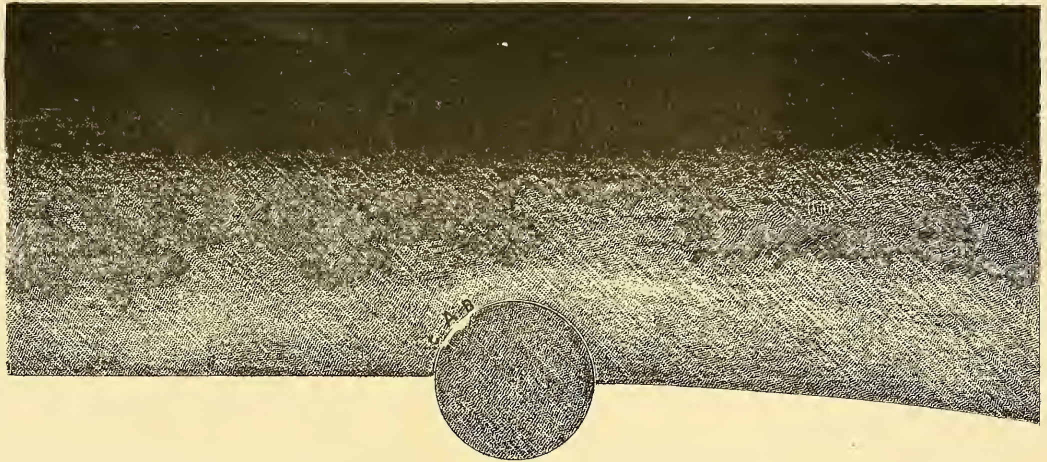
MR HIRST'S OBSERVATONS.

No 2

APPEARANCE DURING ONE VIBRATION

MR. RUSSELL'S OBSERVATIONS

No. 3



HALO AND POLAR SPOT WITH HAZE ON PLANET.

Mr. RUSSELL'S OBSERVATIONS.

LIMBS OF PLANET AND SUN TANGENTIAL

MR. VESSEY'S OBSERVATIONS

No. 5.

THE TRANSIT OF VENUS AS OBSERVED AT EDEN.

By the Rev. Wm. Scott, M.A.

[*Read before the Royal Society*, 11 *January*, 1875.]

We left Sydney on Tuesday, November 24th, and arrived at Eden the next morning. Having landed our observatory, tents, and instruments, together with a good supply of bricks and cement for building piers for the instruments, my first care was to find a suitable spot for the observatory. I was not long in selecting an open space known as the Market-square, on a hill overlooking both bays. This site has the advantage of being near the telegraph line, and commanding uninterrupted views of the ranges at some miles distance to the south and west, the wooded sides of which I saw would afford good reference marks for the adjustments of the transit instrument in the meridian and prime vertical. The day was nearly over before we had carted all our baggage to the top of the very steep hill which forms the principal street. A commencement however was made of setting up the observatory, in which we were most effectively assisted by Mr. Russell, the Harbour Master, and his boat's crew. On Saturday everything was ready, with the exception of mounting the equatorial telescope, which was delayed in order to allow the pier to become quite dry. An approximate meridian had been determined by sun observations with a theodolite.

Our instruments were—the $7\frac{1}{4}$-inch equatorial telescope formerly used in the Sydney Observatory (with good driving clock), a portable 2-inch transit instrument, a 4-inch and a 3-inch telescope, the theodolite before mentioned, a clock and three chronometers. The upper portion of the observatory was provided, besides the usual shutter, with a frame fitting the opening, to which was attached a bag of yellow calico, of somewhat conical form, having a hole in the smaller end, through which the telescope and finder could pass. This bag being secured round the middle of the telescope tube, excluded all but yellow light, so that the whole observatory answered the purpose of a dark room for photographic work.

This arrangement, though very convenient, was, I think the least successful of Mr. Russell's contrivances, as the bag was liable to be influenced by the wind, and so to interfere with the steady motion of the telescope. All being ready, I waited anxiously for a clear night to enable me to make the necessary star observations for time and instrumental adjustments; but so unusually cloudy was the weather that I could get no satisfactory observations until Saturday, December 5. On the 7th and 8th I exchanged longitude and clock signals with the Sydney Observatory, but on each occasion was prevented by clouds from getting more than one transit observation.

On the 7th, being a clear day, we took two sets of photographs to satisfy ourselves that all was in good working order, and found that by reducing the aperture of the telescope to three inches the sun's edge was more sharply defined and the reference lines more clearly distinguished.

In our trial observations of the sun several of our dark glasses were cracked by the heat; so finding that I could get no sufficient protection even with the 3-inch diaphragm, I constructed one 2 inches in diameter, which gave very satisfactory results.

In consequence of the continued cloudy weather my instrumental adjustments were not so accurate as I wished. I was assisted one day in adjusting the reference lines in the camera by a small well defined solar spot, which appeared to traverse one of the lines with great accuracy. In order to correct any remaining error in the position of the lines, I adopted the plan recommended by Mr. Russell of taking two photographs of the sun, at an interval of about a minute, on the same plate, and determined to repeat the process at every half-hour during the transit. Now, in order to make this double image of any service, it is necessary that the common tangents to the two images should be exactly parallel to the direction of the sun's motion. For this purpose the telescope must remain perfectly at rest, and therefore must not be touched during the interval.

This result appeared difficult to obtain, as the flashing shutter must be made to cross the field a second time for the second image. The method which I contrived, though somewhat complex, appears to be perfectly satisfactory.

The flashing shutter, as described by Mr. Russell in his paper read before the Society on September 3, 1873, is attached to the end of a lever, which is drawn down by an elastic band, when the other end is released by pressing a spring. If the second image were obtained by raising the shutter quickly by the hand at the end of the desired interval the action of so raising it would probably displace the telescope; or if the dome shutter were closed, or a cap placed on the telescope, and the flashing shutter restored to its former position and again released, there would be the same risk and almost certainty of displacement. To overcome this difficulty I arranged as follows:—For distinctness I call the end of the lever to which the shutter is attached A, and the opposite end B. I attached a piece of wood to the camera so as to project over B. An elastic band secured to the camera below, and enclosing B, was tied by a string to this projecting piece, so as to allow B to move freely within it. When a double image is to be taken, the telescope is so adjusted, by the help of the finder, that a little more than half of the sun shall appear in the photograph. The driving clock is then stopped and the photograph taken in the usual way. The telescope remains at rest for a minute; meanwhile the band which pulled down the flashing shutter is cut with a sharp pair of scissors, and at the end of the minute the string which holds the band at the end B is cut; B is thus drawn down and A flies up with the flashing shutter, so that a second image is taken. As an elastic band is cut each time, it is necessary to have as many bands round the camera at A, and as many loops of string at the piece over B, as there are double images to be taken.

On the morning of the 9th the weather seemed promising. I obtained clock signals from the Sydney Observatory, and by 11 o'clock we were all collected and anxiously waiting for the transit to commence. Clouds were coming up and the wind rising, and we had reason to anticipate a disappointment. At the time of ingress, however, the clouds had not yet intervened. The exact instant of first contact it was impossible to determine. Mr. Mac Donnell recorded 11h. 56m. 29s. Sydney mean time as the moment at which he became quite convinced that the transit had commenced. I found my 2-inch aperture answer admirably, not only from the diminished light and heat, but also from the great distinctness of the outlines of the sun and planet. I soon became convinced that all we had heard and read respecting the apparent elongation of the planet's disc, and formation of what has been described as the "drop," was a delusion. For some minutes before internal contact I could see clearly the whole of the planet's outline; in fact, it presented exactly such an appearance as might have been expected from a planet possessing an atmosphere. Whilst the direct light of a portion of the sun was shut out by the intervention of the planet, a sufficient portion of that light reached the eye by refraction, through that atmosphere, to render the whole outline visible. By means of a double-wire position micrometer, I obtained a measurement of the apparent diameter of Venus; then, bringing one of the wires into the position of a tangent to the sun's limb, waited until the planet seemed to touch the other wire. This occurred at 0h. 21m. 7s., though Mr. MacDonnell, who judged the same phenomenon by the eye, unaided by a micrometer, placed it nearly two minutes earlier, or at 0h. 19m. 24s. This I believe to be the most important determination, being the moment of complete ingress; and I regret that the action of the wind on the telescope rendered it impossible to keep the micrometer wire in its true position as a tangent to the sun's limb. Still, I consider the above result to be very near the truth. I continued to watch the planet for more than three minutes, and saw the partial obscuration of the sun's limb by the planet's atmosphere gradually diminishing until it disappeared altogether, when I left the telescope at 0h. 24m. 48s. Mr. MacDonnell's estimate of the same phenomenon was 0h. 25m. 14s. The discrepancy between Mr. MacDonnell's results and my own shows how impossible it is to fix the moment of a phenomenon of the kind, when the motion is so slow and the change from darkness to light so gradual. The slow rate of the planet's motion across the sun's disc may be estimated by considering that it occupied over four hours in describing so small an arc, not far exceeding one half of the sun's diameter. The difficulty was still further increased by the planet's path not being at right angles to the sun's limb, but inclined to it at an angle of about 32 degrees.

It may be asked why is the obscuration noticed on the outer edge of the sun and not all round the planet. The answer is, that rays from a much smaller portion of the sun are refracted to the eye through the atmosphere near the point of contact than through the other parts.

As soon as we had concluded that ingress was complete, the 3-inch diaphragm was substituted for the 2-inch and we proceeded to take photographs, but in doing so we were very much impeded, and the quality of the pictures affected by the clouds which were continually driving over the sun's face: indeed there were very few minutes during which the sun was not more or less obscured. Again the action of the wind on the yellow bag was so great that the driving clock became almost useless, and I was obliged to hold the telescope as best I could, with my eye at the finder, whilst the plates were inserted and the flashing shutter released. We made two attempts at a double image, but of course the results were quite unreliable. On the whole we took about fifty photographs, very few of which I fear are of any value. At one time we had to stop for twenty, and at another time for eighty minutes, the sun being entirely obscured. On the whole the expedition to Eden has not been a success, and I came away under the impression that Eden, though a beautiful spot, and in many respects a most desirable place to inhabit, is about the worst place for astronomical observations that I ever visited.

The Longitude of the Eden Observatory, as determined by transits of stars at Sydney and Eden, recorded in the same chronograph, is 9h. 59m. 36s.25, and the Latitude by transits on the prime vertical is 37° 3′ 47″.

Sydney: Thomas Richards, Government Printer.—1875.