AFFILIATED WITH THE ASSOCIATIONS OF ONTARIO LAND SURVEYORS AND BRITISH COLUMBIA LAND SURVEYORS.

REPORT OF PROCEEDINGS

—OF THE—

ASSOCIATION

—OF—

Dominion Land Surveyors

AT ITS

NINTH AND TENTH ANNUAL MEETINGS,

HELD AT

OTTAWA IN FEBRUARY, 1892 AND 1893.

Ottawa:
PRINTED FOR THE ASSOCIATION BY JAMES HOPE & CO.
1893.

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ASSOCIATION OF DOMINION LAND SURVEYORS

Organized April 24th, 1892.

OFFICERS FOR 1893.

HONORARY PRESIDENT.

THE SURVEYOR GENERAL.......................................Ottawa, Ont.

PRESIDENT.

JOHN McLATCHIE, D.L.S.......................................New Edinburgh.

VICE-PRESIDENT.

D. C. MORENCY, D.L.S.......................................Quebec.

SECRETARY-TREASURER.

J. I. DUFRESNE, D.T.S.......................................Ottawa, Ont.

EXECUTIVE COMMITTEE.

W. OGILVIE, D.L.S.......................................Ottawa, Ont.
SAMUEL BRAY, D.L.S.......................................Ottawa, Ont.
W. S. DREWERY, D.L.S.......................................Victoria, B.C.

AUDITORS.

A. ST. CYR.......................................Ottawa, Ont.
P. R. A. BELANGER.......................................Ottawa, Ont.

LIST OF MEMBERS

—OF THE—

Association of Dominion Land Surveyors.

1893

HONORARY MEMBERS.

NAME.	TITLE, ETC.	ADDRESS.
BELL, R.	B.A., Sc., C.E., M.D., L.L. D. Assist. Director G. and N. H. Survey of Canada.	Geological Survey, Ottawa, Ont.
BOULTON, J. G.	Staff Commander, R.N.	Ottawa, Ont.
DAWSON, G. M. D.	Sc., Assoc. R.S.M., F.G.S., F.R.S.C., Assist. Director G. and N.H. Survey of Canada.	Geological Survey, Ottawa, Ont.
DEVILLE, E. G.	F.R.A.S., D.T.S., F.R.C.S., Surveyor General, Pres. of Board of Examiners for D. L. and D.T.S.	Topographical Survey, Department of Interior, Ottawa, Ont.
CALBRAITH, J.	M.A., D.T.S., Professor of Engineering, School of Practical Science, Toronto.	70 St. Mary St., Toronto, Ont.
HARRINGTON, B. J.	B.A., Ph. D., F.G.S., F.R. C.S., Prof. of Chemistry, etc., McGill College.	Walbrae Place, University St., Montreal, Que.
KING, W. F.	B.A., D.T.S., Chief Astronomer of the Department of the Interior, Member of Board of Examiners for D. L. and D.T.S. International Boundary Commissioner.	Topographical Survey, Department of Interior, Ottawa, Ont.
MACOUN, J.	M.A., F.L.S., F.R.C.S., Botanist and Naturalist.	Geological Survey, Ottawa, Ont.
MAGRATH, B.	P.L.S., Inspector of Schools, Member of Board of Examiners for D.L. and D.T. S.	Aylmer, Que.
SELWIN, A. R. C.	C.M.G., LL.D., F.R.S., Director of the G. and N. H. Survey of Canada.	Geological Survey, Ottawa, Ont.
TACHE, E. E.	Assist. Comm. of Crown Lands.	Crown Lands Department, Quebec.

ACTIVE MEMBERS.

NOTE: All active members are Dominion Land Surveyors. The following abbreviations are used in the present list of members, viz:

D.T.S., for Dominion Topographical Surveyor.
O.L.S., for Ontario Land Surveyor.
P.L.S. Que., for Provincial Land Surveyor for Quebec.
P.L S.B.C., for Provincial Land Surveyor for British Columbia.
P. L. S. Man., for Provincial Land Surveyor for Manitoba.

NAME.	TITLE, ETC.	ADDRESS.
BEATTY, W.	O.L.S.	Delta, Ont.
BEAUDRY, J. A. U.	C.E., P.L.S., Que., Architect.	107 St. James St. Montreal, Que.
BERLINQUET, F. X. T.	P.L.S., Que., Resident Engineer P. W. Department.	Three Rivers, Que.
BOWMAN, H. J.	O.L.S., C.E.	Berlin, Ont.
BRABAZON, S. L.	P.L.S., Que.	Portage du Fort, Que.
BRABAZON, A. J.	P.L.S., Que.	Dept. of the Interior, Ottawa, Ont.
BRADY, J.	M.E., O.L.S	Thunder Hill Mine, *via* Golden, B.C.
BRAY, SAM.	O.L.S., C.E., Member of Executive Committee.	Department Indian Affairs, Ottawa, Ont.
BRAY, E.	O.L.S.	Oakville, Ont.
BREENE, THOS.	P.L.S., Que., Resident Engineer.	P. O. Box 1041, Quebec.
BROWNLEE, J. H.	O.L.S., P.L.S., Man.	Victoria, B.C.
BURKE, W. R.	O.L.S.	Ingersoll, Ont.
CHALMERS, T. W.	Insp. N.W. Mounted Police.	Fort Saskatchewan, N.W. Ter.
COTE, J. L.	P.L.S., Que.	Ottawa, Ont.
COZENS, J.	O.L.S., Town Engineer.	Sault Ste. Marie, Ont.
CRAWFORD, WM.		Winnipeg, Man.
DENNIS, J. S.	D.T.S., Insp. of Surveys.	Dept. of the Interior, Ottawa, Ont.
DICKSON, H. G.	P.L.S., Man.	Silkirk, Man.
DOUPE, J. L.	P.L.S., Man.	Winnipeg, Man.
DREWRY, W. S.	O.L.S., P.L.S., B.C., A.M. Can. Soc. C.E.	Dept. Lands and Works, Victoria, B.C.
DRISCOLL, F.		New Westminster, B.C.
DUMAIS, P. T. C.	P.L.S., Que.	Hull, Que.
DUFRESNE, J. I.	D.T.S., P.L.S., Que., Member of Board of Examiners for D.L. and D.T.S., Sec. of D.L.S. Association.	Department of Interior, Ottawa. Ont.
DUFRESNE, L. A.	P.L.S.	Windsor Mills, Que.
FAWCETT, T.	D.T.S., O.L.S.	Department of Interior, Ottawa, Ont.
FONTAINE, L. E.	P.L.S., Que.	Levis, Que.
FREEMAN, N. A.		Milton, U.S.
GARDEN, J. F.	O.L.S.	Vancouver, B.C.
GAVILLER, M.	C.E., O.L.S.	Collingwood, Ont.

NAME	TITLE, ETC.	ADDRESS.
GIBBONS, J.		Renfrew, Ont.
GORE, T. S.	O.L.S.	Victoria, B.C.
GOSSELIN, L.	P.L.S., Que.	40 Bridge St., Quebec.
GOSSELIN, P.	P.L.S., Que.	305 St. Joseph St., Quebec,
GREEN, T. D.	O.L.S.	Ottawa, Ont.
HARRIS, J. W.	P.L.S., Man., Sec. P.L.S. Asso. of Manitoba.	Winnipeg, Man.
HENDERSON, W.	P.L.S., B.C.	Ruisseau a l'Eau Chaude, Dorchester, Que.
IRWIN, H.	B.A.L.C.E., P.L.S., Que., Assist. Engineer C. P. Ry.	103 Union Avenue, Montreal, Que.
JEPHSON, R. J.	O.L.S., P.L.S., Man.	Calgary, N.W. Ter.
KIRK, J. A.	O.L.S.	New Westminster, B.C.
KLOTZ, O. J.	C.E., D.T.S., Member of the Board of Examiners for D.L. and D.T.S.	Department of the Interior, Ottawa, Ont.
LAURIE, R. C.	P.L.S., Man.	Battleford, Sask, N.W.T.
LEWIS, J. B.	O.L.S., P.L.S., Que.	126 Sparks St. Ottawa, Ont.
MACMILLAN, J. A.		Calgary, N.W. Ter.
MADDOCK, J. A.	O.L.S.	Duarte, Los. Angelos Co., Cal., U.S.A.
MAGRATH, C. A.	D.T.S., L.C.N.W. Coal and Navigation Co.	Lethbridge, Alberta, N.W. Ter.
MOUNTAIN, G. A.	O.L.S., Chief Engineer, C. A. R.	Ottawa, Ont.
MORENCY, D. C.	P.L.S., Que., Inspector of Surveys, Que., Member of the Board of Examiners for D.L. and D.T.S. Vice-President of Asso. D.L.S.	Levis, Que.
MURDOCK, W.	P.L.S., New Brunswick. C.E. of St. John and Portland.	P. O. Box 275, St. John, N.B.
McAREE, J.	D.T.S., O.L.S., M.E.	81 Rose Ave., Toronto, Ont.
McARTHUR, J. J.	P.L.S., Que.	Dept. of Interior, Ottawa, Ont.
McLATCHIE, J.	O.L.S., P.L.S., Que., President of the Asso. D.L.S.	New Edinburgh, Ottawa, Ont.
NELSON, J. C.	In charge Surveys of Indian Reserves.	Department of Indian Affairs, Ottawa, Ont.
NIVEN, A.	O.L.S.	Waliburton, Ont.
OGILVIE, WM.	O.L.S., Member Executive Committee Asso. of D.L.S.	Department of the Interior, Ottawa, Ont.
PATTEN, T. J.	O.L.S.	Little Current, Ont.
RAUSCHER, R.	P.L.S., Que.	Department of the Interior, Ottawa, Ont.
REID, J. L.	O.L.S.	Prince Albert, N.W.T.
RITCHIE, J. F.		Nelson, B.C.
ROBERTSON, H. H.	P.L.S, Que.	St. Thomas de Montmagny, Que.
SIROIS, J. E.	P.L.S., Que., Hydrographic Surveyor.	St. Anne de la Pocatien, Que.

NAME	TITLE, ETC.	ADDRESS.
SEWELL, H. DEQ.,	O.L.S., M.L., C.E.	Port Arthur, Ont.
STARKEY, S. M.	P.L.S. for New Brunswick.	Starkey, N.B.
STEWART, L. B.	D.T.S., O.L.S.	School of Practical Science. Toronto, Ont.
SULLIVAN, H. O.	P.L.S., Que., Inspector of Surveys for the Province Quebec.	Jeune Lorette, Que.
SULLIVAN, J.	P.L.S., Que.	Valleyfield, Que.
ST. CYR, A.		Department of the Interior, Ottawa, Ont.
SYMMES, C. T.	Engineer, Linea de Falca a Constitution R. R.	Telca, Chili.
TALBOT, A. C.	P.L.S., Que.	Montmagny, Que.
TALBOT, P. C.	P.L.S., Que.	Montmagny, Que.
THOMPSON, W. T.	D.T.S.	Qu'Appelle Station, N.W. Ter.
VAN NOSTIAND, A.J.	O.L.S.	Room J, Young St., Toronto,
VICARS, J.	O.L.S.	Kamloops, B.C.
WILKINS, F. W.	D.T.S., O.L.S.	Norwood, Ont.
WHITCHER, A. H.	P.L.S., Que., Member of the Board of Examiners for D.L. and D.T.S.	Department of the Interior, Ottawa, Ont.
WHEELER, A. O.	O.L.S., P.L.S., Man., P.L. S., B.C.	New Westminster, B.C.
FRASER, J. W	Topographical Draughtsman.	Public Works Department, Ottawa, Ont.

ASSOCIATE MEMBERS.

CUMMINS, A. P.	C.E.	Donald, B.C.
CLAYTON, F.	Surveyor and Draughtsman.	Department of the Interior, Ottawa, Ont.
DOWLING, D. B.	B. A., Field Explorer and Topographer.	Geological Survey of Canada Ottawa, Ont.
FRASER, J. W.	Topographical Draughtsman.	Public Works Department, Ottawa.
McNUTT, C.	B.A., M. and C.E.	Viola Mining and Smelting Co., Comas, Idaho, U.S.
ODELL, C. M.	C.E.	North Sydney, Cape Breton, N.S.
SMITH, J.	C.E. Draughtsman.	Department of the Interior, Ottawa, Ont.
SYMES, P. B.	A. of A.S., King's College.	Department of the Interior, Ottawa, Ont.

NOTE: Should there be an error in the name, standing or address of any gentleman in the foregoing list, the Secretary-Treasurer will be not only happy to correct the same in the next issue, but will be very much obliged for any information that will enable him to do so.

RESUME OF PROCEEDINGS

OF THE

NINTH ANNUAL MEETING

OF THE

Association of Dominion Land Surveyors.

The Ninth Annual Meeting of the Association was held on the 16th and 17th February in the Lecture Room of the Literary and Scientific Society, Sparks Street. The Meeting was attended by over 30 members and the lectures attracted a large audience.

In accordance with the Rules and Regulations adopted by the affiliated Associations the meeting of the Convention of Canadian Land Surveyors was held and in the same room on the afternoon of the 16th February. Delegates from the Association of Provincial Land Surveyors of Ontario and from the Association of Dominion Land Surveyors only were present, the scheme of affiliation having been adopted by the Association of British Columbia too late to send delegates. Several questions of importance to the profession were submitted to the Convention.

The next meeting of the Convention will be held in Toronto. It is to be hoped that the Convention will soon include all the Associations of Land Surveyors in the Dominion and thus secure unity of action in any direction that may be decided for the advance of the profession.

The President's Address, which appears below, is very comprehensive, refers to the work of the Executive Committee, and make especial reference to affiliation and to a Trigonometrical Survey of the Dominion.

The following papers of interest were read:—"Are the Great Lakes Retaining Their Ancient Level?" "Photo-topographical Surveying," "The History and Use of the Arithometer," "Geographical Nomenclature," "A Latitude Attachment for the Transit," "Irrigation," "Latitude by Elongation," "Notes on Maps and Map-making," "Exploratory Surveys," "The Process of Photo-lithography" and a paper on "Amber."

Prof. Macoun delivered a very interesting and instructive lecture on the "Topography, Flora and Faunal of the Rocky Mountains National Park." A valuable and instructive paper on "Star Distances" was also read by the Chief Astronomer, Mr. King, D.T.S.

The Sub-Executive Committees for British Columbia and Manitoba submitted Reports, on which action will be taken.

The Report of the Scrutineers of Ballots showed the following officers elected for 1892:—

President—John McLatchie, D.L.S.
Vice-President—J. I. Dufresne, D.T.S.
Secretary-Treasurer—Samuel Bray, D.L.S.
Executive Committee—{W. H. Drewry, D.L.S. / Wm. Ogilvie, D.L.S. / D. C. Morency, D.L.S.}
Auditors—{T. D. Green, D.L.S. / P. C. Talbot, D.L.S.}

The Sub-Executive Committee are the same as last year. The following standing commistees have been appointed:—

Permanent Marking of Surveys—H. Irwin, W. S. Drewry and J. U. Beaudry.

Natural History—Prof. Macoun, J. J. McArthur and Thos. Fawcett.

Instruments—O. J. Klotz, J. I. Dufresne and L. A. Dufresne.

Geodetic and Topographical Surveying—D. C. Morency, Wm. Ogilvie and A. O. Wheeler.

The exchanges for the year have not yet been decided, but it is probable that no change will be made.

The annual dinner was thoroughly enjoyable, and an exceptional success.

The success of the Association is assured; it only remains for every member to keep in view the fact that to attain a maximum of usefulness, not only the collective, but the individual assistance also of all members is required.

PRESIDENT'S ADDRESS.

To the Members of the Association of Dominion Land Surveyors:

Gentlemen,—

It affords me very great pleasure to welcome you to this the Ninth Annual Meeting of our Association.

There is no provision in our constitution for an annual address from the President, but it has become a custom to lay before you each year, through the medium of this address, a brief account of the proceedings of the Association since the last Annual Meeting, and to make such suggestions as may be considered, by the retiring President, of value and importance and worthy of consideration by the incoming Executive Committee.

The programme which the Committee have been able to provide for this meeting is a lengthy one and contains many subjects of interest and value to our members. In addition to the usual papers and lectures our programme contains the proceedings of the first convention meeting under the scheme of affiliation with the Provincial Association of Ontario, and the reference to this subject leads me to speak of the general subject of

AFFILIATION.

At our last Annual Meeting a committee was appointed to attend the Annual Meeting of the Ontario Association to discuss with them, and if possible to arrange the basis of affiliation of the two Associations. Having personally taken a great deal of interest in this important matter it affords me very much pleasure to refer to the success which attended that meeting, one result of which was seen in the Convention Meeting held this morning at which subjects of interest to both Associations were discussed and reported upon.

Within the past few weeks the Association of Provincial Land Surveyors in British Columbia has accepted the scheme of affiliation and our future Conventions will represent these three Associations.

I feel certain that beneficial result will follow this Union of Associations and look for important and lasting benefits to our profession from the Annual Meeting together of representatives in Convention to consider subjects affecting us as a body of professional men in the Dominion.

EXECUTIVE COMMITTEE.

Since our last Annual Meeting nine meetings of the Executive Committee have been held, and many matters of interest to the Association have been considered.

The routine matters are dealt with in the report of the Secretary-Treasurer, the only question among those considered and acted upon by the Committee which it is necersary to bring before this meeting is explained by the following

NOTICE.

The Association of Dominion Land Surveyors having been informed that persons who are not qualified Surveyors are making surveys of town plots, and doing other survey work, notice is hereby given that only those duly qualified, and holding Commissions as Dominion Land Surveyors are authorized to make surveys, and the attention of interested parties is drawn to the fact that plans and surveys made by any persons other than Dominion Land Surveyors cannot be registered, and such surveys have no legal standing.

J. S. Dennis, D.T.S.

Pres. Assoc. of D.L.S.

This notice was sent to members of the profession and to all Registrars, Postmasters and Dominion Land Agents in the North West, and it is hoped that it will aid in stopping the practice of unqualified persons.

SUB-EXECUTIVE COMMITTEES.

The Sub-Executive Committees in Manitoba, the North West Territories and British Columbia have rendered valuable service to the Association during the past year. Reports from these Sub-Committees will be submitted to you, they contain important questions for consideration and action by the meeting. It is recommended that these Committees be reappointed and become a permanent feature of our organization. In connection with the duties of these Sub-Committees I beg to call attention to the necessity of action being taken by the Association and the Sub-Executive in the North West Territories to protect the rights of our profession in any legislation which may be passed by the newly created Legislative Assembly for the Territories relating to surveys and surveying. No doubt legislation in that direction will be considered before long, and we should take steps to prevent, if possible, any infringement of our rights.

STANDARD MEASURES.

The President in his address at our last Annual Meeting spoke of the erection of an apparatus in this city for the purpose of testing our standard steel tapes. You will, I know, be glad to hear that this apparatus is now in working order, and that surveyors can procure the standards provided by law, and are thus enabled to keep that important instrument, the chain, of proper length. As a matter of interest to our members we have provided in our programme for a visit of inspection to see this apparatus in use.

INCREASED MEMBERSHIP.

It is a matter of great gratification to be able to report a material increase in our membership during the past year. Our roll now stands 11 Honorary members, 77 Active members and 9 Associate members. It is earnestly hoped that members of the Association will, during the coming year, try and induce those Dominion Land Surveyrrs who have not yet done so to join the Association and help on the good work we are trying to acomplish.

As an inducement to membership I would call attention to our

REPORTS AND EXCHANGES.

During the past year our members have received the annual report of our Association and the reports of the Associations of Michigan, Illinois, Ohio and Arkansas. They have also received the report of the Department of the Interior containing information relating to the season's surveys, and 30 copies of the report of the Geological Survey (which are sold at $2 per volume) have been distributed. These reports, containing as they do valuable information on all professional subjects, are of themselves a handsome return for the small annual membership fees.

GEOGRAPHICAL NOMENCLATURE.

This important question is receiving careful consideration at the hands of the Department of the Interior, and the gentleman charged with the duty of correcting the inconsistences and absurdities in the nomenclature of our maps has kindly consented to address this meeting on the subject. Much of the success hoped for in this matter will depend upon the co-operation of the members of the profession, and I bespeak for it the interest and attention which its importance warrants.

TRIGONOMETRICAL SURVEY OF THE DOMINION.

Probably the most important question before the profession as a whole is the inception of a trigonometrical survey of the Dominion upon a basis which would provide for co-operation between the Federal and Provincial Governments. This subject has received considerable attention at our hands in the past, and as there seems to be little doubt that it rests with the surveying profession to impress upon the proper authorities the importance and necessity of this work. I am pleased to say that our Standing Committee on this subject will at this meeting submit an exhaustive report which will I hope receive careful consideration at your hands.

ANNUAL DINNER.

The Annual Dinner having proved a successful feature of the last two meetings, the Executive Committee feel that it has become an important part of our programme, and they trust that your liberal support will make this year's social gathering a complete success.

In conclusion, Gentlemen, I have to thank you for the honour due me in electing me your President during the past year, and at the same time to express to the Executive Committee and members generally, my appreciation of the readiness shown by all in assisting me to perform the important duties connected with my office.

Respectfully submitted,

J. S. DENNIS.

President.

REPORTS.

REPORT OF THE SECRETARY-TREASURER.

To the Officers and Members of the Association of Dominion Land Surveyors.

GENTLEMEN,—

Your Secretary Treasurer respectfully reports that the Minutes of our proceedings and paper read at the last Annual Meeting of the Dominion Land Association were arranged and edited for publication as early as possible, but due to delays the printer brought to his part of the work, the report was issued, ready for distribution, only on the 9th of September.

In the last term of office over 250 letters have been sent and about 200 received, not comprehending in these the destribution of three or four circulars that were issued.

A few members have been struck off the roll for non-payment of past dues.

Messrs. Jas. McEvoy and E. M. Coste have tendered their resignation, both expressed their regret for taking this step and they presented their best wishes towards a continuation of prosperity to our Association.

We have all to regret the demise of one member who had been with us since the first days of our Association; Major A. C. Webb.

I know that I express the feeling of the members of this Association in saying that in our departed friend we have sustained the loss of one of our most distinguished members.

Two new members have joined our Association since last meeting; they are Mr. Henry Sullivan, Inspector of Surveys for Quebec, and Mr. John Sullivan, Dominion and Provincial Land Surveyor.

Our list of Membership is as follows: 78 Active Members, 9 Associate Members and 11 Honorary Members, making a total of 98 Members.

Exchanges of our report with the reports of the following Societies has been made during the year; viz:—With the Association of Civil Engineers and Surveyors of Ohio, Illinois and Michigan.

Copies of these exchanges have been distributed to every member of the Association.

The Arkansas Society had accepted our exchange and the necessary number of copies of our report was accordingly sent to them, but subsequently they decided to make a joint report for 1891 and 1892, and therefore their report for 1891 was not printed.

The Secretary of the Arkansas Society stated further that he would send in copies of their report for distribution to the Members of our Association as soon as it be issued.

The Indiana Engineering Society favored us with some 30 copies of their Annual Report, on application members will be furnished with a copy of this report until they have all been disposed of.

Thirty copies of the Geological Survey Report were received in accordance with an order in council passed to that effect, and of these 16 copies were distributed according to a list prepared by the President.

The maps to be appended to this report were not ready and they are to be supplied as soon as issued.

The Association was presented with the complete works of Mr. le Chevalier Chs Baillargé, City Engineer of Quebec.

These works are a valuable addition to our library.

Mr. le Chevalier Baillargé was tendered with a motion of thanks for his appreciated gift.

Allow me gentlemen to take advantage of my leaving the office of Secretary-Treasurer, to make the following remarks :—

The position of Secretary-Treasurer to our association involves both the work of many long hours and responsibility.

It is the duty of each member to help this self-devoting officer, the first and most important step to take is to prevent unnecessary correspondence.

The Executive Committee has thought it necessary to request me three times to send the same accounts with accompanying letter, in order to collect the dues of more than a few members.

An unpaid officer will, with difficulty, take interest in his work when he is placed in such a position. As to the responsibility of the office of Secretary-Treasurer, this could be lessened in a very great measure as far as the present system of balloting for election of officers is concerned. I would suggest that each voter would endorse with his signature, the envelope containing the folded ballot, this would be a protection to the Secretary-Treasurer.

As it is now, the name of the Secretary only appears on the envelope of the ballot, and with the present system in force how would the Secretary-Treasurer answer to a charge of non-producing the original ballot papers.

I hope, gentlemen, that my services as your Secretary-Treasurer have been of the kind I endeavored them to be and that my efforts to promote the interest of the association have not been in vain.

J. I. DUFRESNE,

Secy.-Treasurer.

THE ASSOCIATION OF DOMINION LAND SURVEYORS AND THE ASSOCIATION OF PROVINCIAL LAND SURVEYORS FOR ONTARIO, HAVING AGREED TO BECOME AFFILIATED. THE FOLLOWING RULES AND REGULATIONS ARE ADOPTED TO GOVERN THE RELATIONS, MEETINGS AND ALL TRANSACTIONS OF THE AFFILIATED SOCIETIES :—

RULES AND REGULATIONS.

1. The affiliation of the two associations shall not interfere with the individuality or autonomy of either associations.

2. Each association shall continue the issue of its annual report; the proceedings of the convention of the affiliated associations being published in manner hereinafter provided.

3. Each association shall at its Annual Meeting appoint a delegation of five members to represent it at the Annual Meeting of whichever association is acting as the Convention Meeting as hereinafter provided, the Committee formed of these delegations to be known as the Convention Committee. All matters of mutual interest between the two association to be decided by a majority of the votes of the said delegations. The chairman of the delegation of the association at whose headquarters the Convention meets to be chairman of the above Convention Committee.

The proceedings of the Convention Committee shall be governed by the rules of Parliamentary procedure and a copy of the same furnished each association who may incorporate such portions of the proceedings as they may see fit in their Annual Reports. Each delegation to have 5 votes either in person or by proxy, if any member of the delegation finds it impossible to attend, his vote shall be exercised by the chairman of his delegation.

4. The Convention Meetings shall commence in the year 1892, and shall be held each year thereafter. This meeting shall be called "The Convention of Canadian Land Surveyors." The first of these meetings shall be held in Ottawa, and the subsequent meetings shall be held in Toronto and Ottawa alternately.

5. The Convention Committee shall arrange the programme for the convention, and all papers, reports, etc., which are sent to the two associations and which would be read at the Annual Meeting of the associations, or appear in the reports of the associations for the year in which the convention is held, shall be submitted to the Convention Committee and they shall select therefrom such papers, reports, etc., as they may consider proper to be read or presented to the convention. All papers, reports, etc., shall, however, remain the property of the association to whom they were originally submitted.

6. Nothing shall be presented to the convention which properly pertains only to one association, and all papers read and discussions by the convention shall be such as interest or affect the profession of land surveying as a whole.

7. Each association agrees to amend its constitution and by-law where neceseary, so as to bring these rules and regulations into effect.

8. Each association agrees to say on the first page of their annual reports "Affiliated with the Association of Dominion Land Surveyors" or "Association of Provincial Land Surveyors for Ontario," as the case may be.

9. Each association binds itself to admit any other association of Land Surveyors in Canada to affiliation upon the acceptance by such association of these rules and regulations.

10. Any proposed amendments to these rules and regulations after their acceptance by both associations must be sent to the Secretary of each association at least one month before the date of meeting of convention, and such proposed amendments shall be set forth on the notices of convention meeting.

11. All voting by the Convention Committee shall be an open or standing vote, a majority of the votes cast to decide questions.

12. Each association agrees and hereby binds itself to do everything necessary to strengthen the hands of the Convention Committee by supporting them in all matters which affect the profession of Land Surveying as a whole.

This is the scheme of rules and regulations adopted by the P.L.S. Association of Ontario and by the deputation acting on behalf of the Association D.L.S.

J. S. DENNIS,

TORONTO, March 12th, 1891. *President Assoc. D.L.S.*

TENTH ANNUAL MEETING.

The following circular was sent to the members of the Association after the 10th Annual Meeting, it speaks for itself, and is published here as a record and also as a resume of the proceedings of the meeting:—

OTTAWA, March 18th, 1893.

SIR,

The Annual Meeting of the Association of Dominion Land Surveyors was held in the Ottawa Bank Chambers on the afternoons of February 21st, 22nd and 23rd.

The routine business was transacted; the result of the letter ballot being as follows, viz:—President, John McLatchie; Vice-President, D. C. Morency; Secretary-Treasurer, J. I. Dufresne; Executive Committee, W. S. Drewry, S. Bray and W. Ogilvie; Auditors, A. St. Cyr and P. R. A. Belanger.

It was decided to publish an annual report for 1893.

The Executive Committee desire to explain why a report was not published in 1892.

During the first years of the Association the reports issued were small and the cost of printing not large, so that there was a considerable surplus in the treasury. But as members became interested they contributed papers of great interest and value not only to the profession but also to the public at large. Kindred Associations all over America desired to exchange with us and so great was the demand that 1,000 copies of our report were required to fill it. To provide funds for publishing this large number the membership fee was raised to $3.00, but we regret to state that many members have failed to pay this small amount and the result has been that liabilities were incured to such an extent that in 1891 the Executive Committee were compelled to use their private funds to the extent of nearly one hundred dollars.

The Committee therefore did not feel like assuming the whole responsibility for 1892 and an appeal was made to members to pay up dues and for contributions.

The response has been sufficient to pay off outstanding debts so that now there is a balance of $90.00 dollars in the treasury and the dues of many members yet to be collected. In addition to this the members resident in Ottawa have contributed upwards of seventy dollars, so that a report for 1893 can be published; although it is probable that unless the members in arrears pay up promptly some of the papers now in the hands of the committee cannot be published this year if a sufficient number of copies for exchanges with other Associations is printed.

The Executive is sanguine for the future if the members will pay up with reasonable punctuality. It may be added that it has been decided to withold reports and exchanges from those who do not remit fees.

Yours very sincerely.

J. I. DUFRESNE,

Sec.-Treasurer.

SECRETARY-TREASURER'S REPORT.

The President, Mr. John McLatchie, being absent since the fall of 1892, on a survey in the North of Ottawa Valley, no address of the President was read.

It may be added that the Executive Committee have decided to leave until the next report the publication of the different reports of the standing committees.

OTTAWA, 21st Feby., 1893.

Association of Dominion Land Surveyors.

MR. CHAIRMAN AND GENTLEMEN,—

I consider that I have been unfortunate in having filled the office of Secretary-Treasurer during the past year, the first for many that the Association has not published the Annual Report of its proceedings; at the same time it has also been fortunate as it would have been almost impossible for me to have devoted the necessary time to the proper preparation of the report for the printer.

For the same reason, that is, that my time is so fully occupied, I have been obliged to retire from the Secretaryship, although I assure you, were it possible, it would have given me great pleasure to have served the Association as its Secretary.

The amounts of money received during the past year are as follows:—

Balance received from 1891	
Arrears for 1892 and previous years	$ 57 50
Donations	58 45
Sales of Annual Reports	54 00
Fees for 1893	1 50
	90 00
Total	$ 261 45

The total Expenditure is as follows:—

Payment of note representing the unpaid expenses of last year	
Rent of rooms	$ 138 75
Printing	4 00
Type-writing	17 75
Postage	12 00
Stationery	11 55
Express charges	3 50
Duty on advertising card	3 90
Discount on note	36
	25
Total	$ 192 06

Thus leaving a balance of $69.39 in favour of the Association.

I think we may congratulate ourselves on the very good prospect that the incoming Association year will be a very successful one, and it is to be hoped that the finances of the Association will be so managed in the future as not to again necessitate retrenchment by omitting to publish the Annual Report of its proceedings.

SAM. BRAY,

Secy.-Treasurer.

REPORT OF AUDITORS.

To the Vice-President and Members of the Association of Dominion Land Surveyors.

GENTLEMEN,—

We, the undersigned Auditors, appointed by your Association, beg to report that we have examined the accounts of the Sec.-Treasurer and find them to be correct and well kept.

T. D. GREEN,
A. C. TALBOT, } *Auditors.*

OTTAWA, Feb. 23th, 1893.

PAPERS.

[This Association is not responsible as a body for any opinions expressed in its papers by members.]

IRRIGATION LEGISLATION: ITS PRIMARY PRINCIPLES.

In concluding the paper I had the honor of submitting three years ago in this Association, I stated that my object in writing it was merely to direct attention to the general object of Irregation, leaving to the future a further elaboration of it.

If any excuse were needed for again referring to this question, its importance might be justified by instancing the attention devoted to it in almost every agricultural community, from the earliest times to the present. Among the nations of antiquity cultivation by irrigation was the rule rather than the exception. The great kingdoms of Babylon and Assyria were dependent on the artificial use of water for their food supplies. The land of the Pharaohs', the granary of the ancient world, would have been an unproductive desert had it relied on the dropping from the clouds to raise its marvellous crops. The India that Alexander conquered had a wonderful system of water storage and distributing. The aqueducts of the Romans are well known. And though these mighty empires have passed away, the system of agriculture they employed yet flourishes. Egypt still chiefly raises its produce by the artifical application of water and one of the principal causes which have contributed to the great advancement that country has made since it came under British and French control has been the attention which the representatives of those powers have caused to be directed to the restoration and construction of irrigation works. Since the British Government has assumed the management of affairs in India, it has spent millions of pounds in endeavouring to renew the decayed reservoirs and canals of its ancient rulers and in planning and executing new storage places and distributing channels on a tremendous scale. To this, in connection with railway construction, is attributable the very great advance made by India in recent years as a producer of cereals, an advance which has caused no little consternation amongst the older suppliers of the world's market for these commodities. The phenomenal progress Japan is now making is in no small degree because of the improvements it has effected in its irrigation works. A considerable improvement in the condition of Turkey, China and other Asiatic nations would also, no doubt, be observable were their irrigation systems extended and modernized. But it is not merely ancient nations, or barbarous peoples, or tropical and semi-tropical countries that have resorted to irrigation. In Italy, especially in Lombardy, and in parts of France and Spain, the artificial application of water to growing crops is extensively resorted to. Even in England itself, a country where there is no lack of moisture and where the science of Agriculture has probably reached its highest development, the irrigation of certain crops is by no means unusual. In the British Colonies outside of Canada there is no subject relationg to agriculture which is receiving so much attention as irrigation. In both Australia and South Africa a great deal of study is being devoted to it, and vast engineering enterprises for improving the water supply are in contemplation and course of construction. Coming to this continent we see that one of the most important subjects which has lately occupied the attention of the United States Congress is that of the water supply of their Western States and Territories, where irrigation is at present very extensively practiced but where it is capable of infinitely greater development.

Under these circumstances, a consideration of the question of irrigation ought not, in any case, to be unprofitable in a country so dependent on Agriculture as Canada, even were the only possible interest we could have in it that of knowing something of the methods of cultivation our competitors are employing. But, as mentioned in my previous paper, there is in our own North-west a certain area which, to be developed to its fullest capacity, will require the aid of irrigation. This gives us a personal interest in the consideration of the question. With the vast extent of unsettled lands we have that are susceptible of cultivation without the regular employment of irrigation, it would be folly to pretend that the North West cannot progress for many years and in a marvellous degree without giving any thought to its dry portions. But we may well revolve in our minds whether it would not be wise to make such provisions in our laws that any immigrants who may come to us, and who, having been accustomed to farming by irrigation, may desire to settle in a portion of our territories possessing in some respects similar characteristics to the country they have left and to follow in their new home the same system of Agriculture they pursued before coming to it, can in a profitable manner and without injury to subsequent arrivals, utilize the water supplies which can be made available for the irrigable area. The idea that people can be found willing to go to the trouble of irrigating their farms when, elsewhere, they can obtain free of cost a fertile and easily worked homestead capable of producing most excellent crops without the artificial application of moisture, may to some appear preposterous. But that such is the case is demonstrated by the experience of the United States, where pioneers have voluntarily passed by the excellent land of the prairies to locate in the arid desert, which, by irrigation, they have made to blossom as the rose and where, they state from experience the profits of agriculture are greater and more certain. Surely if such settlers can be obtained it is not good policy to discourage their coming in and developing, free of cost to us, that part of our country where the rainfall is scanty, simply by not providing legislation on the subject of water rights. That our irrigable area will at some time or other be developed there can be no reasonable doubt, and deferring the consideration of the question of legislation concerning the water supply we shall be storing up for ourselves complications and disputes, which when development does commence will materially retard it. This has been the experience of other countries, and there is no reason why, by a little foresight, we should not avoid for ourselves the mistakes they have fallen into. Apart altogether from the question of the development of our region of scanty rainfall, there is no doubt that the productive capacity of districts plentifully supplied with natural moisture could be greatly increased in certain respects by the application of water. I have already referred to the fact that this method of cultivation obtains to a considerable extent in European countries where the rainfall is by no means small. There is not the least doubt that for certain crops (the cultivation of timothy, vegetables, small fruits, trees, shrubs, etc., for instance) it could advantageously be brought into us, and certainly will be brought into us before very long by some of our enterprising farmers, in what may even be termed the humid portions of the Territories.

For these reasons it may be useful to call attention to certain principles in connection with irrigation legislation which we should not overlook in any regulations we may formulate, whether speedily or at a more distant date, for the control of water in the North-west.

We can gather a great many hints from the experience of the United States in dealing with this question. In that country the construction of irrigation works and the application of water to lands has been left to private enterprise under regulations provided by the State Governments. The result of this system has been that the water supply in the arid portions of the West is not being used to anything like the best advantage. In consequence of the ignorance or cupidity of individuals or corporations a great deal of waste of the precious fluid, which is practically of more value than the land it is applied to, is taking place. In the first place, there has been no regular system of dividing the country into water districts. The States and Territories are arbitrary parallelograms which do not conform to the water-storage areas. A large number of rivers and streams run through several States. The Agriculturalists in the neighbourhood of the headwater of a stream, so long as they are able to secure all the water they desire from it, care nothing whatever for those in another State through which the stream may afterwards run, and therefore take no pains to make the most economical use possible of the water they abstract from it. This, in fact, is the case not only as between different states but as between different water districts in the same State. Quarrels and disputes on this account are of very frequent occurrence, and the State Courts have been kept busy in deciding the difference between individuals and districts. The present condition of affairs is one that may be very profitable for lawyers, but certainly is not in the general interest of agriculture. The regulations of the different states vary considerably, and this involves different systems in constructing irrigation works. Consequently many undertakings are of a fragmentary character and cannot be prosecuted so cheaply or so profitably as if they could be carried on independently of State boundaries and under uniform regulations. Another cause of waste and inconvenience is because there was not any proper and extended topographical survey before irrigation became general to determine what lands could be permanently irrigated, to apportion the proper water supplies to the proper districts, and to provide for the preservation of catchment areas. Now, so many interests have arisen that to systematize matters will be most difficult, if not quite impossible. Water is being relegated in some districts of land where the climate and soil are unfavorable to agriculture, and again it is being used on lands so far away from the source of supply that a vast quantity is lost in conveying it thither. Many early settlers who settled some distance down a stream and at one time had plenty of water for their wants, now find themselves suffering from scarcity because newer comers have settled further up stream and diverted their supply. Information to guard against errors of this kind cannot be obtained by individuals, for to arrive at it technical skill must be employed, innumerable circumstances must be considered and great accuracy in calculation exercised. From a consideration of these difficulties it is evident that, to avoid disputes and to ensure the most economical management of the water supply in our irrigable districts, the matter of irrigation should be under the control of the Central Government instead of being left to the haphazard regulation of different local authorities. The North-west not yet being carved into provinces, it will be possible to make provision when the Territories are admitted to the Provincial Status to reserve this as one of the subjects on which the Dominion Parliament may exclusively legislate. The necessity of a thorough survey of the irrigable area to indicate the best districts for permanent irrigation, the chief sources of water supply, how by the construction of dams and reservoirs that supply can be augmented and the best division of the country into water districts, as suggested in my former paper, is also made apparent. Not only its necessity, but its immediate necessity. If this matter be delayed too long, we may find, as the United States is now finding, how difficult it is to evolve order from chaos.

Another very important point which has been much debated elsewhere and which we should settle in Canada before commencing irrigation legislation, is whether it is advisable that the construction of irrigation works should be left to private enterprise or should be performed by Government. There appears to be very much stronger arguments in favour of the Government making public works of irrigation canals and reservoirs than can be advanced for its undertaking many other enterprise which it is frequently contended it should take charge of. In our case the greater portion of the lands in the districts to be benefited by irrigation belong to the Government and they will be very greatly enhanced in value by the construction of irrigation works. Water in a country dependent on irrigation is so precious that it is a duty the Government owes to the community, or, in other words, that the community owes to itself, to prevent its being captured by monopolists and sold to the farmers, who must buy it at any cost, at extortionate prices. For the proper and most economical utilization of the water supply it frequently happens that works must be constructed of too great magnitude for ordinary individual or corporate effort or of such a nature that for a considerable length of time no adequate remuneration will be derived from them, and therefore when left to private enterprise, irrigation must necessarily be conducted on somewhat a "one-horse" scale, which means waste and only partial development, in other words a considerable loss of national wealth.

It would not seem an unreasonable question that the Government should assume the responsibility for what may be called the trunk canals and the most important reservoirs, leaving to local or municipal organization, in the shape of "water districts," the construction of small branches and store basins and the management of the distribution of the supply to individuals in their respective districts.

It is of course possible, and in fact it is very probable, that some individuals or corporations will be found desirous of commencing operations before the Government is prepared to go into the construction of works of this nature, when, indeed, the demand for water for application to land would be so small as not to justify the expense of the building of a comprehensive system of reservoirs and canals. In cases such as this it would be manifestly wrong to discourage private enterprise. The plans for such private works should, however, be carefully examined by the Government Department charged with the control of irrigating matters, to see that they do not involve waste of water, and will not clash with the general plan the Government has formed for the most economical irrigation of the district where they are located, or other districts in that neighbourhood. In Spain, the Irrigation Regulations provide that water privileges granted organizations for the distribution of water to the lands of others are to be the property of the grantees temporally, the concessions being for a limited term, at the expiration of which the works and rights pass to the land-owners using the water from the works, and these land-owners and users of water are entrusted with the management of the works. This system, or a similar one, might be adopted in the North-west until the Government is prepared to go into the question, the works so constructed reverting at the end of the time limited to the Government instead of to the land-owners.

In this connection attention may be called to the necessity of stringent provisions to compel the proper registration, within a limited time, of water rights by individuals or companies going into irrigation enterprises. A neglect of this precaution has caused no end of litigation in the State of Colorado.

Whether irrigation be left to private enterprise or be made the subject of Government control, there is one important preliminary principal which should without delay be established, without the recognition of which no comprehensive scheme can be carried on. This principal is, that water is the property of the public. I venture to quote on this point from the legislation of the State of Colorado concerning irrigation:

"Sec. 5. The water of every natural stream not heretofore appropriated within the State of Colorado is hereby declared to be the property of the public, and is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided.

"Sec. 6. The right to divert unappropriated waters of any natural stream for beneficial uses shall never be denied. Priority of application shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the services of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes."

This principal is opposed to English law, and may at first appear repugnant as calculated to interfere with private rights. It appears to have aroused considerable opposition in Colorado when first established, but those who were formerly its bitterest opponents are now found ready to confess its wisdom and the advantages it has resulted in. When it is remembered that in our Mining Regulations we adopt practically the same principal the novelty of it disappears. At present there are few vested interests to be interfered with, and no time is more favorable for passing the necessary legislation than the present. Where any private rights to water can be shown to have been acquired previous to the legislation in question, it will be possible to deal with them by means of expropriation should occasion require.

To avoid the round-about process which expropriation entails, the Government might consider the advisability of reserving a right of way for the construction of irrigation canals and other works when granting patents for land in the districts where irrigation may be necessary or advantageous; otherwise it may be possible for selfish land-owners to delay works of great public benefit. It is the custom of the Government to reserve right of way for railway purposes and also for stock-watering purposes when issuing patents, and a reservation such as now suggested cannot therefore be regarded as unusual or arbitrary.

It appears to me that a proper and timely undertaking of the foregoing considerations will do much to save us from the confusion in which the irrigation question has become involved in other countries. If the limits of this paper allow it, reference might be made to other points we should do well to guard ourselves on. One, for instance, is the necessity of guarding against ambiguity of language in our legislation. In Colorado the expression "domestic purposes" in the portion of the irrigatian laws of that State I have quoted has caused no end of litigation. Another is the necessity of conferring large, and what by some might be considered despotic powers on the officials charged with the regulation of the water supply. Still another is the necessity of adopting a good standard of water measurement. Experience elsewhere has shown that the custom of measuring by the cubic inch has resulted very unsatisfactorily, and the cubic foot is now generally considered a more desirable standard. One further point is the necessity for heavy penalties being imposed to prevent tampering with the headgates of ditches. On all these a good deal might be said.

In conclusion, I may say that I trust my remarks on this subject will be the means of arousing in it the interest of other and abler members of the Association. It is evident that this is a matter in the satisfactory solution of which it will be natural for the profession the Association represents to play a considerable part, for not only does it involve the prosecution of extensive topographical surveys, but it also affords scope for ingenuity in the guaging of streams, in devising an economical flume for the measurement of water supplies to ditches, and in ascertaining what is the "duty of water" in the irrigable tract, which duty will vary according to location and soil. For all these points I feel sure I can bespeak the intelligent consideration of those present.

To the President, Vice-President, and Members of the Dominion Lands Association this is respectfully submitted.

I have the honour to be, Gentlemen,

Your obedient servant,

WM. PEARCE.

I would desire to add the following observations and quotations from acts, addresses and reports on the subject of Irrigation, and trust it may not make the subject too lengthy.

Colorado has the largest amount of irrigation of any State in the Union; after it comes California. I had hoped to embody in this report a review of the legislation under which irrigation has proved so successful in the first-named State, but owing to my not having received a copy of the Act for which I applied, I am obliged to forego my intention. I may mention, however, that according to a report of the State

Engineer of Colorada, it was stated at a Water Convention, held in California in 1888, that those who were competent to express an opinion were unanimous in conceding to Colorada the honor of being, so far as irrigation was concerned, in a position far in advance of California. It is worthy of note, however, that the authorities of Colorado deplore the condition of legislation there, which they consider to be not nearly so far advanced as might be desired, and as the requirements of their State demand. One of the chief difficulties which have had to be met was the impossibility of getting decisions through the courts as speedily as they desired, decisions which affected materially the water supply—the life of the country. They say that too much time was taken up first in raising the question, and next in deciding it. Colorado started with her irrigation legislation in 1881, and every session of the State legislature—which is biennial—has more or less affected it. So far as my investigation goes, I think that the legislation of Colorado embraces all points of excellence of that of any other State or Territory, and exceeds them so far in progressiveness that a summary of its laws would be amply sufficient for my needs, being absolutely comprehensive, and covering apparently all debatable ground.

I do not think that time should be lost in embodying in our regulations the principle set forth in the Constitution of Colorada, which is as follows:—

"Sec 5. The water of every natural stream, not heretofore appropriated, within the State of Colorado, is hereby declared to be the property of the public, and is dedicated to the use of the people of the State, subject to appropriation, as hereinafter provided.

"Sec. 6. The right to divert unappropriated waters of any natural stream for beneficial uses shall never be denied. Priority of application shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the services of all those desiring the use of the same, those using the water for domestic purposes, shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes."

The principle above established is opposed to the English law, and it would appear that when first proposed it was most strenuously contested by both bar and bench, but those who were then the most strongly in opposition are now the warmest advocates of the same.

The resolutions passed at an Irrigation Convention of the State of California, held in December, 1884, might perhaps be as well reproduced here.

The following is the complete report of the Committee, and every reader of the Register should study it as though his soul's salvation depended upon the understanding of it:—

1. That the cubic foot per second be adoped as the unit of measurement throughout the State.

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2. It is important and desirable to institute a system of making all water rights a matter of proof and record.

3. A declaration by the Legislature that all the waters of the State in natural streams and lakes belong to the people and are subject to appropriation by the people for irrigation, mining, manufacturing and other useful purposes.

4. To provide the machinery for the voluntary formation of irrigation districts, by which the owners of lands may acquire water rights, and assess the land for the purposes of constructing canals, ditches or other irrigation works, or for purchasing those already constructed;

Provided, that waters already appropriated shall thereafter be utilized as at present through existing works or the extension of the same, as far as may be necessary for the irrigation of the lands dependent thereon; and further provided that no lands shall be taxed for the construction of works of irrigation except lands actually to be irrigated by said works.

5. To so extend the law of Eminent Domain as to allow an irrigation district or a corporation outside of an irrigation district, to condemn and pay for rights of way, land, canals, ditches and water-claims and rights of whatever nature held by any person or corporation, or any other private rights of property, however existing, or acquired, or by whatever name designated, which may be necessary for the appropriation or use of water;

Provided, that in condemning water used at the time of the commencement of an action for the same, a manifest great or public interest shall be shown.

That the irrigation district with power to condemn is defined as the sub-district within the hydrographic district at present without condematory power, but with regulation power only.

6. To provide for a thorough and complete actual accounting for all the waters used by any and all districts and companies, and for a proper distribution of the waters of any stream between appropriators, and for such other police regulations as may be necessary.

(a) Where there is so great a diversity of opinion, as now exists in this State, as to what the law is in relation to water rights, it is clearly the duty of the law making power to so improve it as to leave it free from all ambiguity and leave it definite and easy to be understood by the people and the courts.

(b) That the legislature has this power, is made plain by Sec. 2, Article 1 of the constitution which reads as follows:—"All political power is inherent in the people. Government is instituted for the protection, security and benefit of the people, and they have the right to alter or reform the same whenever the public good may require it.

(c) The Constitution of our State recognizes and sanctions the appropriation of water, and does not recognize or sanction the doctrine of riparian rights. Its language is as follows:—"The use of all water now appropriated, for sale, rental or distribution, is hereby declared to be a public use and subject to the regulation and control of the State, in the manner to be prescribed by law."

(d). Title 8th of the Civil Code, providing for the appropriation of water, is the law of the state, and whenever the Common Law of England is antagonistic to or inconsistent with any section of said title, it has no force or effect as law in this State.

(e) Law it defined by our Code, "as the will of the people solemnly expressed."

As to No. 1 the usual mode of measuring water is by the Cubic inch and is universally condemned by those who have given the subject considerable study, in fact, it is utterly impossible to measure water according to the law of the State of Colorado, when it is in a considerable quantity, and in practice it is measured by the foot, and some nice points of law have arisen out of this, so that in providing legislation this must not be lost sight of.

As to No. 2, this is a matter that would not greatly affect us here, there being so little water now used; it is a point however that has been the cause of a considerable amount of difficulty in Colorado so that in the event of our compiling regulations it will be well to bear this in mind, and allow only a limited time—say six months—within which to record any waters then being used.

The proviso to section 4 is worthy of attention and that is that although anyone may have recorded a large volume of water, he shall be allowed to take in time of scarcity only what is beneficial to him for the land under cultivation, and no more. During the dry season of (I think 1887) in Colorado it being found that there was insufficient water for both irrigation and domestic purposes, the Court enacted as follows:—

"And the Court does further find and declare as a matter of law, that the uses to which water may be applied which are comprehended by the term 'domestic purposes,' hereinbefore applied and occurring in the constitution of this State, are as follows, and none other, that is to say, household purposes, including water for drinking, washing, bathing, culinary purposes and the like; water for such domestic animals as are used and kept about the home, such as work animals and cows kept to supply their owners and their families with dairy products; and such other uses not being either agricultural or mechanical, as directly tend to secure and promote the healthfulness and comfort of the home."

Supposing B recorded a water claim subsequent to A. If there was not enough water to supply A for irrigation and B for domestic purposes, B was intitled to get whatever water he required for the latter purpose while A had to do without as far as irrigation was concerned. The point thus raised constituted the interpretation of the term "domestic purposes." Some contended however that it also included the irrigation of garden and fruit trees. But the courts held that while the term "domestic purposes" meant the use of water required in the houses of settlers for cooking and cleaning purposes and for stock, it did not include what would be requisite for sprinkling lawns, irrigating gardens and fruit trees. Water, however, required for the purposes of flushing sewers might be included in the term "domestic purposes." It was further found that for the economical use of water it was advisable to supply it only for domestic purposes once a week, thereby effecting a considerable saving in percolation and evaporation. Settlers were required by the authorities to furnish storage for water sufficient to last them the ensuing week and during the continuance of the drought the foregoing system was adhered to. I have drawn attention to these points as it shows the necessity of vesting strong powers in the proper authorities, which might even be styled arbitrary by those unfamiliar with the subject, but which are absolutely necessary in view of contingencies which might possibly arise.

As bearing on the advisability of legislation the following is an extract from an address of the Hon. B. S. Larange, one of the Water Commissioners of the State of Colorado, which was read at a meeting of the Farmer's Institute at Fort Collins. I might mention at present that there is more land irrigation within a radius of thirty miles of Fort Collins than in any similiar area in the United States.

"Previous to 1880, a conflict of interest had grown up as such irrigation enterprise progressed. The laws of the State afforded no adequate method for adjustment. Every water user, private or corporate, became the opponent of all others. There were no definite rights, and in case of conflicting claims, the only remedy was a resort to the courts; and then, in most cases, the claim could be but partially established as against some particular rival claimant. The policy of the State was to leave the distribution of the water from the stream to the several claimants thereof, and the settlement of all disputes to the courts. The general government might just as well have thrown open the public domain to appropriation; have no regulations, require no proof of claim except when disputed in the courts. There would be no basis of credit in lands, and no limit to the requirement of large holdings. It is just this policy which the State pursued towards the irrigation interests, a free-to-all rule, which brings trouble to all. A non-intervention policy on the part of the Government of a country never has, nor never can solve the problem of irrigation.

"How then do we acquire a right to water? The whole foundation of the water system is its use. Whoever has acquired a legal vested right to the use of water, and has need for the same, must be protected at all times in the enjoyment of its use. But whenever that need ceases, then it becomes the property of the public. Segregation must be made before we can get possession. Once in possession it becomes property, coupled always with a beneficial use and no waste.

"Owing to the climatic conditions and atmospheric influences on our water sheds, the water is ever variable in amount, constantly slipping from the grasp, ever moving onward, wasting in many ways an element of wealth, temporarily and at not very regular periods, and then in quantities rarely sufficient for all, and is most precious at the time of least supply, and should be administered in a manner that the public will derive the greatest possible benefit. Our lands are worthless without water, and the State should give equal protection to the ownership of water as well as to the land."

Colorado, wherever it is settled, either in manufacturing, mining, or agricultural interests, is divided into water districts: in fact the whole State is so divided. Each district has a Commissioner, who is appointed by the Governor of the State from amongst a list submitted to him by the several Boards of Commissioners into which water districts may extend.

The following extracts from the regulations of the State bear upon the duties and appointment of the Water Commissioner:

"Sec. 42. There shall be one Water Commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the Governor, to be selected by him from persons recommended to him by the several boards of County Commissioners of the Counties into which water districts may extend, and the Water Commissioner so appointed shall, before entering upon his duties, give a good and sufficient bond for the faithful discharge of his duties, with not less than three sureties, in a sum not less than one thousand and not more than five thousand dollars, the amount of said bond to be fixed by the County Commissioners, and approved by the Governor and State Engineer. The Commissioner so appointed shall hold his office until his successor is appointed and qualified; Provided, however, that if such water district shall be embraced in more than one county, and the several counties in which such water district is situated, disagree as to the amount of the bond herein required of the Water Commissioners, then and in that event the Governor shall fix the amount thereof, with the same effect as though fixed by the County Commissioners."

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DUTY OF WATER COMMISSIONERS—OPEN AND SHUT HEAD-GATES.

"It shall be the duty of said Water Commissioners to divide the water in the natural stream or streams of their district among the several ditches taking water from the same, according to the prior rights of each respectively; in whole or in part to shut or fasten, or cause to be shut or fastened, by order given to any sworn assistant-sheriff, or constable of the county in which the head of such ditch is situated, the head-gates of any ditch or ditches, heading in any of the natural streams of the district, which at a time of a scarcity of water shall not be entitled to water by reason of the priority of the rights of others below them on the same stream."

The State is further divided into water divisions, the intention being that all water districts, or portions thereof, upon any one stream shall be grouped into one division. The Superintendent is appointed, without being recommended by any one, by the Governor of the State, and his duties are defined as follows:

"The Governor shall appoint a Superintendent of Irrigation for each of the water divisions now existing within the State, or which may hereafter be created; such superintendents of irrigation to hold office for a period of two years from the date of their respective appointments, or until their successors shall be appointed and qualified. The Governor may, at any time, in his discretion, remove such superintendents of irrigation, or any of them, and appoint others in their stead, for the remainder of said term of two years; Provided, that the Governor shall not appoint a Superintendent of Irrigation in any district until the Board of County Commissioners of some one or more of the counties whose territory, or any part of whose territory, is included in such water district shall have, at a meeting regularly called and held, adopted a resolution requesting such appointment to be made, and have had the same certified to the Governor. Said Superintendent of Irrigation shall have general control over the water commissioners of the several districts within his division. He shall, under the general supervision of the State Engineer, execute the laws of the State relative to the distribution of water in accordance with the rights of priority of appropriation, as established by judicial decrees, and perform such other functions as may be assigned to him by the State Engineer.

"Said Superintendent of Irrigation shall in the distribution of water, be governed by the regulations of this Act, and Acts that are now in force; but for the better discharge of his duties, he shall have the authority to make such other regulations to secure the equal and fair distribution of water, in accordance with the rights of priority of appropriation, as may in his judgment be needed in his division; provided such regulation shall not be in violation of any part of this Act, or other laws of the State, but shall be merely supplementary to and necessary to enforce the provisions of the General Laws and amendments thereto."

* * * *

"The Superintendent of Irrigation shall receive as compensation, $5.00 a day for every day during which he is employed in the discharge of his duty."

The Superintendent of Irrigation gives bonds to the extent of $5,000. At the head of irrigation affairs is the State Engineer, who by Act of State Legislature, is required to give particular attention to irrigation.

It is worthy of consideration whether it would not be advisable to adopt the principle acted upon in Utah which is the same as in Italy, that is, instead of allowing everyone and anyone to use water just when they think they require it, that the full capacity of the ditch should be turned to each in rotation. To illustrate my meaning, suppose that five men, whom I shall call A, B, C, D and E, obtained water from the same ditch. The combined quantity they take is, say 1,000 cubic feet a day, of which A obtains say, 300 feet. Now, in place of A being allowed to take his proportion day after day, it may be decided that the water shall be obtained only once a week. The ditch would then be turned for A, to its full capacity until he receives his week's supply of 2,100 feet in full and he would not then receive any more for a week. That is the principal adopted, each of the parties having to take his turn. By those competent to judge, it is asserted that this system will give returns from 50% to 100% better than under the old method of water supply.

In providing legislation care will require to be exercised to avoid giving cause for conflict between districts. It has sometimes happened that a certain district has had a sufficient water supply within itself for its needs ; an adjoining district, however, by an extension of its ditches has tapped the sources of the supply of the first, and consequently diminished it, and district number one is at once deprived of its water, and furnished with a serious cause of complaint against its neighbour. This is not an uncommon state of affairs, but is obviously one that should be carefully guarded against. To meet such a requirement, I would recommend that in dividing the country into water districts' its topography should be carefully studied. Major Powell's scheme, which was intended to meet just such a case as the one quoted ; I cannot do better than give his own words in illustration thereof :—

"The waters of the springs flow into creeks and the creeks into smaller rivers and those into greater rivers which ultimately reach the sea. In the main these are the waters which are to be used in agriculture, and by some means they must be divided amongst the different agricultural districts. It is possible to relegate waters to land in the different mountain regions where the climate and soil conditions are unfavourable to agriculture, and this is being done to a large extent at the present time, greatly to the disadvantage of the agricultural interests of the region. It is also possible to relegate waters to lands too far away from the source of supply, so that they are largely lost in the sands of the river valleys through which they pass. Under such conditions only very small regions can be cultivated and the waters are chiefly wasted. For example, it is possible to select lands low down on a given stream where the waters would be sufficient to irrigate only 100,000 acres. But if the same stream could be taken out on lands one or two hundred miles further up, the waters would be sufficient to irrigate one or two million acres of land. This wasteful use of water by selecting lands too far down stream is in progress and needs correction."

"Many of the rivers on which the agricultural lands depend cross State lines, and State is in conflict with State, the lower State protesting against the abstraction of their waters by the States above. These conflicts have become bitter and are likely to lead to serious interstate difficulties.

"Some of the rivers flow part of the way in the territory of other nations, in the British possessions at the North and the possessions of the

Republic of Mexico at the South, and international problems have already arisen and in future they will arise in great magnitude.

"To settle these international problems, interstate problems, and interdistrict problems, all the facts must be collected and set forth to the Government of the United States which is the custodian of the public domain, the agency for the settlement of international disputes, and the authority for the settlement of interdistrict disputes.

"By unregulated and improvident disposal of lands and water rights, the general government is gradually getting into unfortunate relations with the agriculturalists of many districts of the country. It is disposing of irrigable lands to individuals by homestead settlement, preemption settlement, timber culture privileges, and desert land methods, and requiring people to irrigate their lands as part of the contract by which the title to the land passes from the government to the individual. When these people have thus acquired title to their lands by processes of irrigation required of them by the Statutes, they will, in many instances be unable to sustain their rights to the use of the water on the lands which they have selected and redeemed because other persons will have acquired similar rights to other lands above. To protect those above is to destroy those below. One party must have its values destroyed and that party will expect reimbursement for lost values from the General Government. These claims are already appearing in Congress, and in the near future they will appear in large numbers, involving many millions of dollars. The real problem for Congress to solve is this: How can the waters and lands of the arid region be distributed to the people in such a manner that the waters and lands can be used to the best advantage for all the people, that no agricultural industries may be developed on lands where they cannot be maintained, and that interdistrict, interstate and international conflicts may be avoided? The interests involved are of great magnitude. It is possible by the neglect of wise provision to provide for the development of a comparatively large area. Between the minimum and maximum possibilities there is a wide difference, the one being three fold that of the other. Under the best conditions an area of more than 100,000,000 acres can be redeemed by the use of streams while by the most unfavourable conditions from 39,000,000 to 40,000,000 only can be redeemed.

"The information necessary for the people may be briefly characterized in the following manner:—The people should be able to discover what lands can be permanently irrigated, in order that they may occupy them and make their homes thereon, and not make settlements where they must ultimately be abandoned. The people should know definitely and specifically what waters they may be entitled to for irrigation, and that their rights cannot be impaired except by acts of their own. The people settling upon the lands should be informed of the catchment area of the waters which they use in agriculture, in order to protect them. These catchment areas are in the main, mountain forest lands, and on the preservation of these forest lands, the agriculture below depends to an important extent. The people should be informed of the manner by which the water of the streams can be brought to their lands, and how the waters which usually run to waste during the non-irrigating season may be stored in reservoirs to await the time of growing crops when they are needed. These are facts which the settlers—the farmers who develope the country and carry on the agricultural industries—cannot obtain for themselves.

There is another reason for the survey, plainly expressed in the Statute and existing in the conditions under which agriculture in the arid region may be controlled. The Statute provides for the selection and permanent reservation of dam sites, canal sites and reservoir sites, in order that they may be held in the hands of the General Government in trust for the use of the people.

"It is thus that the Director interprets the purpose of organic law of the irrigation survey. That it is the function of the survey to collect information for the General Government, which is the present custodian of the values involved, and the guardian of national and interstate rights, and to collect information for the people who have already settled on the lands and are to occupy them in future, and to preserve great rights and values for the use of the people at large."

Another authority on this same subject might be quoted—the State Engineer for Colorado in his official report for the years 1887-88 says:—

"While the people of Colorado are to be congratulated on the very fine foundation for an excellent code of irrigation laws, afforded by the accepted doctrine of the courts that the first appropriator to beneficial use of the waters of a natural stream has a prior right thereto to the extent of his appropriation, it is to be regretted that the laws on this subject are so ill-arranged and incomplete, and that they fail to effect with any degree of satisfaction the chief end for which they were enacted, namely, to secure the most beneficial use of the waters of the State in the irrigation of lands consistent with the protection of prior rights. It is evident that the time has come for the enactment of a comprehensive code of irrigation laws, founded in equity, planned for the future, wide in scope, specific in detail, protecting vested rights, and encouraging development. The histories of other irrigation countries shows that the longer the preparation of such laws is delayed, the more difficult is their preparation, the more vexing and intricate their interpretation, and the more complicated and expensive their execution.

"If Colorado ever has a complete and effective system of irrigation laws, she will acquire it through the careful study, thorough investigation and persistent labour of a few of her present citizens. It will be the legacy of this to coming generations. Excellency in this matter can only be achieved by men qualfied for the work in many ways. Besides earnestness of purpose, harmony of feeling and freedom from prejudice, there must be among them diversities of talent for the preparation of such a code calls for the most mature and deliberate consideration of men learned in the law, of men versed in the sciences applicable to the art of irrigation, and of men of wide experience in the practice of irrigation."

* * * * *

"Before referring to matters connected with irrigation, which demand the immediate attention of the legislature, it may not be improper to embody herein remarks on the general policy by which it is believed that the irrigation development may be encouraged without incurring the risk of placing the farmers of the State in perpetual bondage to corporations constructing large irrigation works, or yet incumbering the State with the ownership and management of large irrigation works, as is now believed by so many to be desirable. The construction and management of canals and reservoirs by the governments of some of the older irrigating nations have, it is true, proved a benefit to agricultural interests, and those in Colorado who favour the State-ownership and control of ditches and reservoirs may find strong precedent in favour of the position they have taken, in the success of the works so constructed and managed; but there is danger of drawing precedents from the governmental actions of nations having different political and social conditions from our own. Yet there is a policy embraced in the recently revised irrigation law in Spain, which it is believed is applicable to the conditions and general feeling of the people of this State. This is the policy by which water privileges, granted to organizations for the distribution of water to the lands of others, are the property of the grantees temporarily, the concessions being for a limited term, at the expiration of which the works and rights passed to the land-owners using the waters from the works, and those land-owners and users of water are then entrusted with the management of the works under general governmental supervision."

RIGHT OF WAY.

Under the provisions of Congress for what is now the State of Montana, when it was a Territory a free right-of-way for all water canals was provided for across lands owned or controlled by the Federal Government, but whether a reservation was made in the patent for works completed at the time of issuing thereof is not clear. It is apparent, however, that in the Territory of New Mexico no such reservation is provided. In most of the States a free right-of-way is provided across lands owned or controlled by the State, but in the Federal Government there does not appear to be a reservation in the patents for works complete or under construction, or which may be required in the future. In the Act regarding expropriation, or "condemning" as it is termed, for water ditches, it is provided that only the actual damage done shall be paid for, and, further, that free access shall be given; and also that in the repairing and enlarging of ditches similar only, the actual damage done shall be compensated for.

It might be well to reserve in patents issued for lands in the North West in districts where irrigation might be successfully applied, such rights-of-way or other areas as might hereafter be found necessary for such purposes. No one could possibly claim that this would entail any hardship or injury, so long as it did not entail the removal of buildings or in any way endanger their stability. In the majority of cases the water from the irrigating ditch would more than compensate the occupant of the land intersected by it, and even though this might be disclaimed, it cannot but be admitted that the enhanced value of the surrounding lands, by reason of irrigating facilities and consequent increased capabilities of production, must be of advantage.

Facilities for the formation of water-districts, and afterwards divisions with the right to expropriate for right-of-way purposes, would appear to be the first requirement. In many of the States and Territories, such establishment of districts appear to be on the lines adopted in at least parts of Canada for the formation of Statute labour divisions. The construction and management of the canals to carry the water to the locality proposed to be irrigated in many places is levied on the land exactly as Statute labour is. This system, however, is generally condemned by those who have given any considerable attention to the subject as being productive of much misapplied energy.

When in the neighborhood of the Mormon Settlement, during October last, I took occasion to go over a stretch of country that I had not seen before, viz: to the East of the St. Mary's River, Township 1, to Lethbridge. I found an extensive tract of slightly undulating country, with a strong clay soil. I think St. Mary's River could be cheaply brought on to irrigate this tract, and if this were done it would be second to none in Canada. While on this point I would particularly direct your attention to a scheme which Great Northern Railway interests have in view. If international law will permit its consumation, which is to dam the St. Mary's River South of the International Boundary, cut a canal from above the dam to the Milk River, and irrigate along the Great Northern line in Montana. The cost of the dam is estimated at a-quarter of a million dollars, and the cost of the canal a like amount, or half a million dollars in all. This would enable us to irrigate along the Milk River in our territory, but there the valley is narrow and no great quantity could be brought under successful irrigation; whereas, I am told, below Fort Belknap, in Montana, the valley is for a long distance over four miles in width. If it will pay the interests referred to, to spend half a million to get water into the Milk River, would it not be much more profitable that the said water should be used to irrigate the tract mentioned, viz: to the East of St. Mary's River, North of the International Boundary, especially when it can be put on the land at probably one tithe of the cost of the other scheme? Does not international Law prevent the diversion of a stream which is in two countries?

THE MEASUREMENT OF THE DISTANCES OF THE STARS.

A very able lecture was delivered on the above subject by Mr. W. F. King, B.A., D.T.S., etc., Chief Astronomer, and Commissioner for the survey of the territory adjacent to the boundary line between the United States territory of Alaska and Canada.

The following notes taken on this lecture, although giving a resume of it, fails to render justice to the distinguished and learned lecturer.

The measurement of a distance consists in the comparison of it with some unit of length. There is no natural unit of length, or, at least, none that can be used in the present state of science.

All civilized nations have their standard bar-measures; the yard is the British standard. The measurement of any distance, however long, is finding how many times the standard length is contained in the length to be measured; hence the incredible pains, with microscopes, thermometer, etc., which are taken in geodetic operations when long distances are to be measured accurately, to ensure a correct transfer of the standard length to the measures used in the work, for any error in the unit is multiplied by the number of times the unit is contained in the measurement.

The measurement of the distances to the fixed stars depends upon the determination of the sun's distance. On this distance also depend the distance of the planets, their masses, and in fact all the constants of the solar system; therefore, it is desirable that it should be accurately measured. Most of the methods of determining the sun's distance depend upon the radius of the earth, hence to make the treatment of the subject complete, it would be necessary to show how this radius is measured.

This would involve a description of the methods by which the lengths of base rods are found in terms of the standard; base lines are measured with these base rods, long chains and network of triangles are measured from the base line, and, finally, astronomical observations are used to refer the long arcs so measured to the earth's axes.

To enter into any discussion, however cursory, of these methods would make this paper inconveniently long, and I shall, therefore, leave the terrestrial part of the subject, and confine myself to the consideration of how the distances outside of the earth are measured.

The earth's dimensions being known, the most obvious method of determining the sun's distance is for two observers, far apart in latitude, to observe the absolute declination of the sun's centre at the same instant.

Here the lecturer shows how the equatorial, horizontal parallax of the sun can be obtained by such observations. His conclusions are, however, that the equatorial parallax being a small quantity less than 9″, the errors in observing due to refraction, instability of instrumental adjustment, etc., were quite sufficient to swallow up that small quantity; therefore this method is altogether useless.

Another method, which is quite an old one, is analogous to the expansion from a base to the longer sides of a triangulation.

The moon's horizontal parallax is much greater than the sun's, its mean value being nearly 1°, and it can be observed with accuracy; hence is known the moon's distance.

Now, when the moon is at quarter, *i.e.*, when the sun and earth subtend at the moon a right angle, the face of the moon towards us is half illuminated. If, then, when the moon appears as a semi-circle the angle between the sun and moon is observed, we have an angle of a right-angle triangle and one side (the moon's distance) from which to compute the hypothenuse, which is the sun's distance.

This method fails from the impossibility of determining the exact instant at which the moon's disc is half illuminated.

The methods of which practical use can be made are classed under these heads:—

GEOMETRICAL METHODS.

It is a deduction from the law of gravitation, as well as an observed fact, that the planets move in ellipses, having the sun at one focus, and that the squares of the periodic times of different planets (or the lengths of time taken by the planets to move completely round their orbit, from any specified place to the same place again) are proportionate to the cubes of the semi-major axes of their ellipses.

The periodic times can be observed with great accuracy, hence the ratios of the semi-major axes are accurately computed. The other elements of the orbits, the eccentricity, and the position of the apses, &c., are known by observation. Thus the exact orbits of all the planets are found in terms of the sun's mean distance from the earth. All that is necessary then is to find the distance of a planet from the earth, when it is at any known point of its orbit. The solution of a triangle gives the sun's distance.

The distance of the planet from the earth is got by observing its harizontal parallax by observation of the apparent displacement of the planet as seen from two widely separated stations on the earth's surface.

The planet Mars is the most useful planet for this method. The most favourable position for observation is, of course, when it is nearest the earth, that is, when it is in opposition, or on the opposite side of the earth from the sun, for then the distance between the planet and the earth is equal to the difference of the distances of the earth and the planet from the sun. Some oppositions are more favourable than others. Mars has an orbit of considerable eccentricity. At its perihelion it is about 126,000,000 miles from the sun, and at aphelion 152,000,000; hence much the best observation will be got when the planet is at perihelion when in opposition. Its parallax in that case is double what it would be if observed at opposition when in aphelion.

The asteroids may also be used for this purpose. Though further away, and, therefore, having less parallax than Mars, the observation can be made more accurately on account of the smallness of the discs of these planets.

The most approved method of observation of the planetary parallaxes is by measuring the angle between the planet and stars near it in the evening, and in the early morning at a station near the equator. The diurnal motion of the earth changes the place of the observer several thousand miles between the observations. This affords a good base for the triangle, and both angles are measured by the same observer with the same instrument, thus elliminating the effect of personality as well as of many of the instrumental errors.

A favourable opposition of Mars took place in 1877, and the opportunity was taken advantage of to obtain what seems to be a good value of the sun's parallax. Favourable positions of nearer planets occur frequently, and it is probable that observations of their parallax will be multiplied until a very close approximation of the solar parallax will result.

Another geometrical method is that by the transits of Venus and Mercury over the sun's disc. The planet is seen as a small round black spot projected on the luminous disc of the sun.

DELISLE'S METHOD.

If an observer notes the time when the two discs are in apparent contact, either internal or external, he knows that the planet's centre is then distant from the sun's centre by the difference or sum of the semi-diameters of the two bodies. An observer at a distant station will observe this contact at a different time. The difference of the local times of the two observations of the phenomenon corrected for longitude affords the means of calculating the difference of the parallaxes of the two bodies. Then their ratio being known, as above stated, the absolute value of each is found.

HALLEY'S METHOD.

Another mode of observation is for the observer to note the time of the contacts of immersion and emerson. From this is formed the length of the chord of the sun's disc traced out by the planet, and consequently its distance from the sun's centre at nearest approach. Observations at two stations will give different values of this, on account of the displacement caused by relative parallax, thence, as before, is found the absolute parallax.

Delisle's method requires exact knowledge of the absolute movement of observed ingress (or egress as the case may be), whereas, for Halley's method, the determination of absolute moment of ingress and egress is not necessary, the interval between the two being all that is required.

DIRECT METHOD.

This method consists in measuring the greatest angular distance of Venus, while in transit, with the sun's limb at two stations far apart in latitude.

From this measurement and the known proportions of the solar system (in the case of Venus and earth, the relative distances are as 7 to 18), the distance of the sun is deduced.

The suitability of photography for mid-transit observations is obvious; for if, by some trustworthy method of instantaneous solar photography, well defined photographs of Venus in mid-transit can be obtained at suitable northern and southern transits, the sun's distance can be directly determined from careful microscopic measurements of such photographs.

Mercury cannot be used to advantage, on account of its proximity to the sun, and the consequent small amount of the quantity to be measured—the relative parallax. The transits of Venus of 1874 and 1882, are of interest from the large number of expeditions which were sent out to observe them. Unfortunately the results appear not commensurate with the expectations of astronomers, and the great preparations which were made. The determination of the exact moment of contact is a very difficult matter, owing to various causes, especially refraction and personal equation, so that two observers, even at the same place, would differ by many seconds in their estimation of the instant. The observations however were not confined to noting contacts, but micrometric measurements of the distance of the planet from the sun's limb were made at several stations, and at other places photographs were taken, microscopic measurements of which were afterwards made at leisure. These measurements are also encompassed by many difficulties, so that although the results are better than those of the contact observations, yet they are probably not so accurate as those found from the observations upon Mars.

Further transits of Venus have little interest to us, as the next one will not take place until the year 2004. Transits of Mercury are more frequent, but as already stated, they are of little value for parallax determination.

We now come to the second class of methods, namely,

THE GRAVITATIONAL METHODS.

Under the law of gravitation, if the earth and moon were not subject to any external attraction, the moon would describe an elliptic orbit about the centre of gravity of the earth and moon. This is, roughly speaking, the actual orbit of the moon; but both earth and moon are acted upon by the powerful attraction of the sun. This causes pertubations or deviations of the moon from her ellipse. The amount of the disturbing effect at any point of the orbit depends upon the angle at the moon between the attractions of the sun and earth and upon the relative distances of the moon and earth from the sun. When the moon is on the opposite side of the earth from the sun, it is evident that the attraction of the sun upon the moon is less than it is when the moon is between the third and first quarters. Therefore the two parts of the moon's orbit from first to third and from third to first will not be perfectly symmetrical, there will be an apparent irregularity in the perturbations. This variation is called the lunar parallactic inequality. It may amount to 2′, or a little more than 1/15 of the moon's apparent diameter. This small quantity is determined by observation. In the Lunar Theory this quantity is represented in the analytical expressions for the radius vector and longitude of the moon, by terms which involve the ratio of the distances from the earth of the sun and moon; hence a comparison of the observed value of this term with its theoretical expression will give the value of this ratio. The distance of the moon, then being known by the direct observation of its parallax, that of the sun is found.

The observation of this inequality, however, when the utmost refinement of observation is desired, is subject to error from the uncertainty of the moon's apparent diameter, which is different for every instrument, and, probably, for every observer. Thus different calculations of the solar parallax from the same lunar observations differ very greatly among themselves, according to the value which the computer ascribes to the diameter. This difference of results amounts to about one sixtieth of the whole parallax, and hence great exactitude cannot well be claimed for the results.

It has been proposed to observe well-defined spots on the moon's face instead of the limb. This would avoid the difficulty arising from the uncertainty of the diameter, but the method does not appear to have been tried as yet. Many regard this method of determining the sun's distance as the most promising of all the various methods available. Another gravitational method is that by the perturbation of Venus and Mars by the earth's attraction. Certain terms of the orbital theory of these planets increase continually with the time, so that comparison of the places of these planets at the present day with those made in the seventeenth and eighteenth centuries give a good determination of the parallax. The values from Venus and Mars agree very well, and the probable error of the result was estimated by

Leverrier as only one nine hundredth of the whole parallax, or one hundredth of a second of arc.

To give an idea of the smallness of this error it may be mentioned that one hundredth of a second is the apparent diameter of a ten cent piece, held at a distance of two hundred and twenty miles from the eye. Small as this angle is, it represents an uncertainty in the sun's distance of one hundred thousand miles.

THE PHYSICAL METHOD.

We now come to the physical method, or that by the velocity of light.

This velocity is measured by means of a toothed wheel in rapid revolution in front of a luminous point. The light rays after passing between two teeth of the wheel are reflected by a plain mirror, at a distance, back along the same course to the wheel, passing between the teeth of which they are viewed by the observer behind. It is evident that if the wheel is at rest, the reflected light will be seen continually, but if the wheel is rovolved fast enough, the rays passing between two teeth will on their return be encountered by one of them and stopped. The space between the teeth and the distance which the ray has to travel from the wheel to the mirror and back are measured, and the rate of revolution of the wheel when darkness is produced is known. Hence, by a simple calculation the velocity of light in yards or metres per second is found. This method is known as Fizeau's method. Another method, known as Foucault's, is by the revolution of a small plane mirror at the centre of curvature of a small spherical mirror. The plane mirror is set in rapid revolution, and the light falling upon it is reflected to the spherical surface and back to the plane mirror, reflected from which it is viewed into a telescope, the apparatus is so adjusted that when the mirror is at rest the image of the bright point is seen over the cross-hair of the telescope. When the mirror is revolved a displacement is observed of the image. The linear displacement being measured, and the velocity of revolution of the mirror being known, the time of passage of the light between the mirrors is found. This method is the one employed in the more recent accurate determination of the velocity. It is a remarkable instance of refinement with which scientific measurements can be made, that the time of passing of light over a few yards can be measured.

The velocity thus determined is about 186,300 miles per second. Different determinations by different observers agree well together. Now if the length of time required for light to pass across the earth's orbit be found independently, we have at once the distance across.

It was noticed about 1675 by Roemer and Cassini that eclipses of Jupiter's satellites take place later when the earth and Jupiter are on opposite sides of the sun, than they do when the two planets are on the same side of the sun. This difference is found to be about 16⅔ minutes, which is the length of time required for light to cross the earth's orbit. In other words light comes from the sun to us in 8⅓ minutes. This result combined with the velocity of light terrestically observed gives the sun's distance.

Again, the velocity of light and the earth's motion about the sun give us the phenomenon of observation of light. We do not see the stars in the direction in which their light is coming to us. Just as a person running in a perpendicularly falling rain, receives the rain drops obliquely in his face, so the apparent direction of light coming from a star is thrown forward. This causes the stars to move apparently in small ellipses. The semi-major axes of these ellipses are about 20.″4. This number is called the constant of aberration, and represents the ratio of the earth's velocity about the sun to the velocity of light. (The ratio is about 1/1000.) Hence knowing by the terrestrial observations the latter velocity, we know the former also. The earth's velocity per second in its orbit, around which it goes in a year, gives us the circumference of the orbit and thence the radius, which is the distance of the earth from the sun.

The following are some of the values found from the different methods, for the solar parallax :—

From the transit of Venus, 1769, various values have been arrived at by astronomers, varying from 8·″58 to 8·″90.

From transit of 1874, 8·76 to 8·88.

From parallax of Mars observed in 1862, 8·″85 to 8·″96.

By parallax of the asteroid Juno, observed at Mauritius in 1874, 8·″77.

By observation of Mars in 1877, 8·″78.

By perturbations of the moon, different discussions give from 8·″78 to 8·″92.

By secular perturbation of Mars by earth's attraction, 8·″866, and by Venus, 8·″853, according to Leverrier.

By Jupiter's satellites, 8·″76.

By constant of oberration, 8·787.

Taking 8·″785 as the parallax, the deduced mean distance of the sun from the earth is 93,000,000 miles. The error of this result is almost certainly within 200,000 miles.

PARALLAX OF THE STARS.

Having determined the size of the earth's orbit, astronomers make this their base from which to triangulate to the stars. The most convenient unit for stating long distances on the earth, is the mile. The earth's radius is about 4,000 miles. We can form a tolerably clear idea of this distance, when we state the sun's distance as 93,000,000 miles, the magnitude of the number begins to confuse us. But, if we state the stellar distances in miles, we arrive at numbers altogether beyond our grasp. It conveys little meaning to our minds to hear that the nearest fixed star is about 25,600,000,000,000 miles from us, we get a rather better idea from the statement that the distance of the star is 275,000 times the sun's distance.

Even this large unit, however, is inadaquate, so astronomers use a still larger unit for expressing these immense distances. The unit used is itself an immense one. It is called a "light year," being the distance which light travels in a year. Light travels at the rate of 186,000 miles, equal to 7½ times around the earth, in every second of time. It flashes from the sun to us in about 8 minutes. The light from the nearest fixed star takes over 4 years to reach us. This is expressed by stating the distance of the star as equal to 4 light-years.

The distances of the stars are measured by observing their displacement in the sky between observations, 6 months apart, the earth being at opposite points of its orbit. The best results are got, not by observing the absolute position (right ascension and declination) of the star at the two epochs, an operation subject to systematic errors of instrument, refraction, etc., but by observing the relative position of the star and neighbouring stars. The neighbouring stars are chosen by consideration of there want of brightness, or want of proper motion, so that they may be considered as indefinitely remote compared with the star whose parallax is required. The change of position of the star as referred to these stars in the six months determines its parallax, on the assumption that the parallaxes of the companion stars are insensible.

The nearest fixed star is a Centauri, in the Southern Hemisphere; its parallax is ¾ of a second of arc. In other words, the earth's orbit as seen from the star would have an apparent diameter of 1½ seconds. Recurring to the illustration of the 10 cent piece, such an orbit would be covered by the coin placed at the distance of a mile and a half. The actual distance corresponding to this parallax is as before stated, more than 4 light-years. A further idea of the magnitude of this distance can be obtained from the fact that a body placed half way between this star and our sun, and falling into the latter under his attraction alone, would, it is computed, take 500,000,000 years to reach the sun.

The star, 61 Cygni, appears to be the next in the order of remoteness, with a parrallax of half a second, corresponding to 5½ light-years.

Sirius, the brightest star in our sky, has a parallax of 0·"38, with a distance of 9 light-years. The parallaxes of many other stars have been determined, with a remarkable degree of accuracy, when the difficulty of winnowing out of the observations all disturbing effects is considered.

Some of these parallaxes are:

E. Indi, ...	Parallax 0."22, ...	Distance 14½ light years.			
Q. Eridani . .	"	0."165	"	19.5 "	"
G. Toneani . .	"	"06	"	54 "	"

The star Conopus, in the constellation of argo, the brighest star in the sky, after Sirius, is found to have no parallax sensible to the most careful observation. It is thence inferred that its light takes *at least* 65 years to reach us. Other stars have been observed to have a *negative* parallax. The angle at the apex of the triangle is negative, less than nothing, and the three angles of the triangle are less than 180°.

This with observations so carefully made as to preclude the idea of so large an error indicates one of two things—either our notions of space are incorrect, and space has a fourth dimension—or, the more probable explanation, the parallaxes of the neighbouring stars from comparing with which the parallax was derived, are not insensible, as assumed, but are larger than the parallax to be determined.

A parallax of 0."05 corresponding to 65 light years may be taken as the smallest that can be measured instrumentally with any certainty.

The number of stars which have a parallax as large as this is probably not more than a few dozen. For the distance of the innumerable multitudes of more remote stars, other methods, indirect, are resorted to.

One of these indirect methods is that by orders of magnitude. Stars are classed by their brightness, as seen by us, into first, second, third, etc., magnitude stars. By definition, a star of any given magnitude is 2.512 times brighter than a star of the magnitude next below. Since brightness varies inversely as the square of the distance, the relative distance corresponding to one degree of magnitude is the square root of 2.512, that is 1.585. In other words a star of the 2nd magnitude is 1.585 times as far from us as one of the 1st magnitude; a third magnitude star is 1.585 times as far as a second magnitude, and so on, that is, provided the stars are of the same intrinsic brightness. The assumption in this investigation is that they are. This may not be true in individual cases, but when a great number of stars of the same magnitude are considered together, we are probably justified in assuming that on the average their ratios hold. Now by direct observation, it has been determined that the average parallax of stars of the first magnitude in the northern hemisphere is 0."089 corresponding to a distance of about 37 light years. Therefore, on the above assumption, the distance of second magnitude stars is 1.585 times this, that is 59 light years. Third magnitude stars are distant 93 light years and so on. The smallest stars visible in the great Lick telescope are classed in the sixteenth magnitude. If the distance ratio of 1.585 holds, the light of those stars must take 36,000 years to reach us. We see such a star, not in its present place, but where it was 36,000 years ago, and if its light were blotted out at the present moment, we would not be sensible of its loss for that length of time.

The recent application of photography to the stars has greatly facilitated the determination of their parallaxes, and it is to be expected that further investigations in this line will yield interesting results.

The above may be called a statistical method. It aims more at giving average than individual distances. Its application to individual stars is vitiated by the known fact that stars differ in intrinsic brightness. The star a Centauri is at only half the distance of Sirius, yet, it ranks far below it in apparent brightness. Canopus is brighter than 2,500 suns like ours.

There has been a method proposed for finding the distance of binary stars. The term binary star, is applied to two stars associated together—so close together usually in appearance that a good telescope is required to separate them, although, perhaps they may be millions of millions of miles apart—and moving in orbits about their common centre of gravity. A great number of such stars is known, and in many cases they have been observed long enough to enable their elliptical orbits to be plotted.

Now, the light from the further star of the pair will be delayed in reaching us, from having to pass over a greater distance. This will produce deviations in the apparent orbit, from which the dimensions of the orbit can be found, and thence the distances from us by means of the angular magnitude of the orbit. By this method, Savary showed that D Ursae Minoris is at a less distance from us than 109 light-years—but the result is doubtful, and it is unlikely that any precision can be arrived at by this method in the present state of the science. Another proposed method is by spectroscopic observation of binary stars. By means of the spectroscope, it is possible to measure the rate of motion of a luminous body towards us, or away from us.

The apparent orbit of the binary star is measured with angular instruments. This apparent orbit is not the actual orbit, but a projection of it upon a plane perpendicular to the line of sight. Spectroscopic observation gives the relative motion of the two stars in the line of sight, in miles, and thence is found by means of the angular motion, the actual motion in miles in the inclined orbit. This gives the dimensions of the orbit, and then the angular magnitude of the orbit as seen from the earth, gives the distance.

An example of another indirect method of measurement may be given. This depends upon the sun's motion in space.

The sun, carrying with it its system of planets, moves around in space, no doubt revolving, in accordance with the law of gravitation in an orbit about some centre of attraction, as yet unknown to us. The orbit is so immense, that our motion does not sensibly differ from a straight line. It is evident that the stars towards which we are moving will appear to open out and those behind us to close in, by the effects of perspective—the convergence of the rails on a long railway tangent to a vanishing point, is a familiar illustration. The phenomena are, however, complicated by the individual motions of the stars. Each star's proper motion—that is its annual angular movement in the sky—is made up of its individual motion, and the apparent motion imparted to it by our movement in space. These two parts of the proper motion are separated by a calculation based on the theory of vast squares. The result arrived at is, that our sun is travelling towards a certain point in the constellation of Hercules, with a velocity such that the space described in one century subtends an angle of 4·″36 at the average distance of a sixth magnitude star. On the assumption that distance and magnitude are related in the way already described, and that the average parallax of stars of the first magnitude is 0·″089, we find that this velocity is equivalent to about 14½ miles per second. Spectroscopic investigation will in time give us an absolute value for this motion, free from the error which may underlie the above assumptions. In the meantime, we may take the solar velocity as 15 miles per second.

The cluster of stars called the Pleiades, is found to have a common proper motion which is in a direction opposite to the sun's. Hence it is concluded, with a high degree of probability, that their proper motion is a true parallactic proper motion, arising, not from any common movement of their own, but solely from the sun's motion.

The annual proper motion of Alcyone, the principal star of the cluster is 5·″8. This, with the assumed velocity of 15 miles per second for the sun, gives a distance of this star from us of 250 light-years.

A much more accurate determination of the sun's velocity will probably be obtained before many years, and it will then be possible to arrive at the distances of many stars, the smallness of the parrallaxes of which baffle our present means of observation. However, there are many stars whose distances we shall probably never be able to measure. There are stars whose parallactic proper motion is nil, for instance, some stars apparently among the Pleiades, but without doubt, far beyond them, whose proper motion in 45 years is imperceptible.

At 15 miles per second, the sun travels in 45 years some 20,000,000,000 of miles. This enormous distance as seen from the stars, under consideration, vanishes. It follows, that their distance from us is very much greater than that of Alcyone, perhaps even 200 times as much, or 50,000 light-years.

At 186,000 miles per second, 50,000 light-years represent a distance of more than 293,000,000,000,000,000 miles. Two hundred and ninety-three thousand billions (English), or two hundred and ninety-three sextillion (American). Having begun my paper with a yard measure and arrived at a number such as this, I think I have done enough for one evening, and therefore, beg permission to resume my seat.

LATITUDE BY ELONGATION.

In the Sideral Messenger for April, 1891, there appeared an article by Joseph H. Corti, Professor of Geodesy at the National Engineering School of San Juan, Argentine Republic, on "New method for the simultaneous determination of Latitude and Azimuth."

The practical application of the method was new to me, and I determined to apply the method practically, and thereby test its merits, at least for latitude determinations in the field with the D.L. 6-inch transit.*

For azimuth determination the method in vogue by the Department of the Interior, of observing Polaris at any low angle is more convenient and in other respects preferable to the one by elongation. However, it should be stated that the latitude observations at elongation always give the azimuth, the latter being necessary for computing the latitude, hence if desired the azimuth may be utilized for terrestrial objects.

When I wrote my paper last year on "Latitude by Prime Vectical observations," I had not applied the above method and hence the merits of the two for field work could not be compared.

When a star is at elongation we have a right angled triangle formed by the Pole, zenith, and star, and in which we have

$$\sin A = \frac{\cos D}{\cos L}$$

From another star we would similarly have

$$\sin A' = \frac{\cos D}{\cos L}$$

Adding and substracting these two equations, dividing one by the other, and applying the fundamental formulæ for the sum and difference of sines and cosines, we obtain

$$\tan \tfrac{1}{2}(A - A') = -\tan \tfrac{1}{2}(A + A') \tan \tfrac{1}{2}(D + D) \tan \tfrac{1}{2}(D - D) \quad (1)$$

and

$$\tan \tfrac{1}{2}(A + A') = -\tan \tfrac{1}{2}(A - A') \cot \tfrac{1}{2}(D + D) \cot \tfrac{1}{2}(D - D') \quad (2)$$

The first equation is to be applied for two stars on opposite sides of the meridian, that is, when the sum of the azimuths of the two stars has been observed; the second equation for the case when the stars are on the same side of the meridian and the difference of their azimuths has been observed.

The quantities on the right hand of the equation being all known, hence A and A' are readily found.

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*Dominion Lands Transit, three verniers, decimally graduated and reading to °·004.

Knowing now A and A' we have

$$\cos L = \frac{\cos D}{\sin A} = \frac{\cos D'}{\sin A'}$$

In every formula for the determination of time, azimuth or latitude before we begin observing, an investigation is generally made for the purpose of finding what stars are best suited for determining the unknown. This investigation arises from the fact that no observation is perfect, but is affected by small unknown errors of observation.

While an error of observation on a certain star produces a certain error in the unknown sought, an error of equal magnitude made on another star of different declination will produce a different error from the preceding, in the unknown to be determined.

Obviously it is desired that unavoidable inaccuracy in observation shall produce the least error in the unknown sought.

In such investigations recourse is generaly had to the differential calculus.

Differentiating equation (1), remembering that D and D' are constant, we obtain:

$$\tfrac{1}{2} \sec^2 \tfrac{1}{2} (A' - A)(dA' - dA) = \tfrac{1}{2} \sec^2 \tfrac{1}{2} (A + A') \tan \tfrac{1}{2} (D + D') \tan \tfrac{1}{2} (D - D')(dA + dA')$$

Dividing by (1) we get

$$\frac{d A' - d A}{\cos \frac{1}{2} (A' - A) \sin (A' - A)} = \frac{d A + dA'}{\cos \frac{1}{2} (A + A') \sin (A + A')}$$

or

$$\frac{d A' - d A}{\frac{1}{2} \sin (A' - A)} = \frac{d A + d A'}{\frac{1}{2} \sin A + A'}$$

that is

$$\frac{d A' - d A}{d A + d A'} = \frac{\sin (A' - A)}{\sin (A + A')}$$

whence

$$\frac{d A'}{d A} = \frac{\sin (A' - A) + \sin (A + A')}{\sin (A + A') - \sin (A' - A)}$$

$$= \frac{\sin A' \cos A}{\sin A \cos A'}$$

therefore

$$= \frac{\tan A'}{\tan A}$$

$$\frac{d A' + d A}{d A} = \frac{\tan A' + \tan A}{\tan A}$$

where $d A' + d A$ = observed error in azimuth, *i.e.* of reading, $= d R$ therefore

$$d A = d R \frac{\tan A}{\tan A' + \tan A}$$

that is, the error in the deduced azimuth of one of the stars equals the error of reading multiplied by the factor.

$$\frac{\tan A}{\tan A' + \tan A}$$

which is always less than unity.

From our fundamental formula we have

$$\sin A = \cos D \sec L$$

And

$$\text{by } \sin A = \log (\cos D \sec L)$$

Differentiating we get

$$\cot A \, dA = \tan L \, dL.$$

Therefore

$$dL = \cot L \cot A \, dA$$

Substituting in this the value found for dA

$$dL = dR \frac{\tan A \cot A \cot L}{\tan A' + \tan A}$$

$$= dR \frac{1}{(\tan A' + \tan A) \tan L}$$

That is, the error in latitude resulting from the error of reading of the sum of the azimuths of the two stars at elongation, equals the error in reading multiplied by the factor

$$\frac{1}{(\tan A' + \tan A) \tan L}$$

Now A and A' increase as D' and D decrease, and as the tangent increases with the angle, this factor decreases as D' and D decrease; hence it follows, that stars near the zenith are preferable to Polar stars for determining latitude by observing the sum of the azimuths at elongation.

Furthermore, it will be seen that the greater L is, other things being equal, the less will be the factor; or in other words, this method is especially applicable for the more northerly latitudes.

From (2) we would similarly obtain.

$$dL = dR' \frac{1}{(\tan A' - \tan A) \tan L}$$

In order to make this factor as small as possible it is obvious that $(\tan A' - \tan A)$ must be as great as possible, that is D and D' should be close Polar and close zenith stars respectively.

Comparing the two factors.

$$\frac{1}{(\tan A' + \tan A) \tan L} \quad \text{and} \quad \frac{1}{(\tan A' - \tan A) \tan L}$$

It is evident that the second one is the greater numerically, hence the method of observing the sum of the azimuths is preferable to the one of observing the difference at elongation.

Furthermore, more stars are available for the first method than for the second.

In observing, special care must be taken in reading the striding level, and if time permits it should be read before and after each star. The striding level itself should be as good as can be obtained. My experience with striding levels is that there is great room for improvement in their grinding; and even in our small (6-inch) instruments the setting in plaster should be abandoned.

Desiring to observe at some point for latitude by the above method, we first select a pair or pairs of suitable stars, as regards declination and right ascension; the one star east and the other west of the meridian, and so that approximately the hour angle at elongation of the one added to its right ascension equals the right ascension of the other diminished by its hour angle at elongation. Or we may prepare a list of stars arranged in order of time of elongation and observe them accordingly. The grouping into pairs for computing may be done afterwards.

The "Berliner Jahrbuch" is the best catalogue for making the selection.

Knowing the latitude approximately, say within several minutes, we can compute the elements necessary for setting the instrument and finding the star by the formulæ

$$\cos t = \cot D \tan$$
$$\sin A = \cos D \sec L$$
$$\sin h = \operatorname{cosec} D \sin L$$

in which t, A, and h are respectively the hour angle, azimuth, and altitude of the star at elongation.

The level correction for azimuth is deduced from

$$\text{Corr} = \frac{d}{4}\left\{ (w + w') - (e + e' \right\} \tan h.$$

where d = value of one division of striding level.

The observer is supposed to be provided with a sidereal time-piece, and to know its correction. (A good watch will answer the purpose but is not so convenient for stellar observations, where sidereal time only is used). The chronometer correction is readily obtained by observing a star in the vertical of Polaris. This correction need not be known with such great accuracy as is necessary when observing for latitude by Prime Verticals, and herein lies one advantage of this method over Prime Verticals. The other and greater advantage is the great saving of time.

Hours are generally consumed in obtaining satisfactory observations by Prime Verticals on each side of the meridian, whereas with well chosen stars it may not take more than fifteen minutes for obtaining both readings of the two stars at elongation, that is, a complete observation for latitude, by the method of elongation.

When the stars are in the zenith the two methods become identical, for there each fundamental equation gives,

$$L = D.$$

As to the accuracy of results from field observations by the above two methods my experience gives no preference; but for expedition the method of elongation is decidedly to be preferred, and, therefore, recommended for field work.

If the stars are of not too small magnitude the observations can be taken about sundown, when the limb may still be read without artificial light, and no lamp is necessary for illumining the cross-hairs.

In the reduction of the observation it is essential that the declination be accurately interpolated for the particular day, and that Vega's or other 7 place-logarithms for second intervals be used for small angles.

The following is an observation and its reduction.

Place—Grand Rapids, Saskatchewan, September 18, 1892; stars 306 and 220, "Berliner Jahrbuch"; one division of level = 5″·3.

Star.	Elongation.	Horizontal Circle Reading.			Level.	
		A	B	C	E	W
306	E	186°·568	306° 568	66°·566	4·8 6·2	6·2 4·8
220	W	75°.736	195°·736	315°·744	8·3 6·4	2·6 3·2

Mean reading = 186°·5673   75°·7387   D = 62° 07′ 41″·8
Level correction = ·0000 − ·0098   D = 58° 51′ 33″·5

Corrected reading = 186°·5673   75°·7289 $\frac{1}{2}$ (D + D′) = 60° 29′ 37″·65
75°·7289

$A + A'$ = 110°·8384 $\frac{1}{2}$ (D − D′) = 1° 38′ 04″·15
= 110° 50′ 18″·24
$\frac{1}{2}(A + A')$ = 55° 25′ 09″·12

tan $\frac{1}{2}$ (D + D′) = ·2472482   whence A = 51° 14′ 08″ ·90
tan $\frac{1}{2}$ (D − D′) = 8·4553795   and A' = 59° 36′ 09″ ·34
tan $\frac{1}{2}(A + A')$ = ·1615543

tan $\frac{1}{2}(A' - A)$ = 8·8641790
$\frac{1}{2}(A' - A)$ = 4° 11′ 00″ ·22
$A' - A$ = 8° 22′ 00″ ·44

	Check
$\cos D = 9\cdot6697756$	$\cos D' = 9\cdot7136093$
$\sin A = 9\cdot8919439$	$\sin A' = 9\cdot9357776$
$\cos L = 9.7778317$	$\cos L = 9.7778317$
$L = 53^\circ\ 99'\ 42''\cdot13$	$L = 53^\circ\ 09\ 42''\cdot13$

On the same date stars 325, 226 gave $L = 53^\circ\ 09'\ 50''\cdot89$, and on September 17th, stars 306, 220 gave $L = 53^\circ\ 09'\ 39''\cdot50$.

The mean gives for the latitude of Grand Rapids $= 53^\circ\ 09'\ 40''\cdot8$.

I may state that the greatest difference found between independent observations at the various places where observations were made during the past season with a D.L. 6-inch transit (Dominion Lands) was $12''.9$.

I strongly recommend the method by elongation for latitude determination on the Exploratory Surveys where the D.L. 6-inch transit is used.

EXPLORATORY SURVEYS.

In presenting a few remarks on exploratory surveys, I intend as far as possible to avoid all reference to technicalities; such as description and use of instruments, methods of reducing observations, or any other information which can be readily and fully got from works prepared by competent men for use of surveyors generally.

I will confine myself to what might be called the executive part of such expeditions, and merely present what experience has shown me is the most difficult part for a beginner to contend with.

Let it be granted that we are about to conduct an exploration survey which involves an instrumental traverse of a stream or streams —which may be more or less dangerous of decent—and at the end of such survey have to determine by accurate observations the latitude and longitude of our terminal point, or some important point in our line of march.

We will first consider equipment. To conduct such a survey you will require two canoes and a party of four men: if you have only three men and anything goes wrong with one of them, you are at a standstill while he is incapaciated; or, if he is lost, may have to abandon the enterprise altogether—as one man is wholly unfit, except in very smooth water, to handle a canoe of the requisite capacity; and even in smooth water he will not make much headway propelling her. Those four men should all be hearty, lusty fellows, possessed of infinite fortitude and patience, capable of carrying on their back at least one hundred pounds over rough ground and through the woods for a period of at least ten minutes without halting. Your canoes should not be less than 18 feet in length, upwards of 40 inches in width (half a dozen more would be better still), and at least 20 inches deep. Such a canoe will give you satisfaction in every way. A small canoe will be lighter, of course, but will give you infinite trouble and delay. Your outfit will crowd it and sink it so much that you will have very little freeboard; besides, thus loaded, it will actually draw more water than a larger one. Thus cramped you will often find it impossible to proceed through rough water, or in shallow, when a larger canoe would allow advance with ease and safety. Such a canoe, when ready for delivery from the shop, will weigh about 170 pounds, and after a few weeks' use will weigh about 190 to 200 pounds. Two men will soon learn to carry it without much trouble, and it would take two to handle a canoe that would not carry more than half its load. Each canoe should be furnished with not less than four good stiff paddles. The ordinary sporting paddle is much too light for such work as we put them to. Giving them a coat of paint before using them adds much to their life, by preventing warping and splitting in hot weather when exposed to the sun.

As on every such survey more or less portaging has to be done, it is essential to provide a set of pack-straps for each man, and two or three extra sets for use by extra help when it is available. The old-fashioned tump-line, by which the load is supported principally by the neck, is simple and convenient, but requires a lot of practice to develop the necessary stiff-neckedness. Pack-straps which put the whole weight of the load on the shoulders are objectionable, in that they produce paralysis of the arms in beginners and do not permit of the load being readily put down, as with the tump-line. Besides, the load works down into the small of the back and becomes very fatiguing. I have seen a combination of the tump-line and pack strap devised by an old trapper on the upper Ottawa River. It is made by a shoemaker in Mattawa Village, and seems to me just what is required. Tarpaulins long enough and wide enough to cover the canoe completely should be provided against rain storms, and also to cover the stuff at night.

The amount of provisions necessary to start with is, of course, entirely dependent on local circumstances, and will have to be determined by the surveyor taking into consideration all known local facilities for obtaining supplies on the way; but carefully avoid risk by depending too much on such local aid. It is better to have too much with you than to find yourself at some point without food, and unable to get any. I will add as a warning which I cannot repeat too solemnly: "don't depend on your gun or fishing-rod for anything." If you do, you will very likely repent it bitterly. By all means take along a gun, or guns, and plenty of amunition for them, and some fishing tackle, and whatever they bring you is so much gained; but you will probably find at the end of the season that it has cost you more than it is worth. Still, the sport it affords some of us is not to be valued by dollars and cents. You cannot, however, do two things at once; and hunting and surveying are two distinct callings; and, of the two, I think hunting requires the most tact and experience. True, large game once in a while does stumble on to you; but such cases are not frequent, and not at all to be depended on.

Your instrumental outfit will consist of a small transit—or, if you can take two along, it insures you against accident—and some form of micrometer to measure small angles with; the angle, subtended by a constant base, being what you deduced your distances from. The best form of micrometer for this purpose is, I am convinced, the Lugeol—or a modification of it—which has been approved by the Survey's Office, and issued by it for use in this way. I don't think a description of it is necessary here, as it must be familiar to nearly all of you. The results obtained by this instrument, under good conditions, with a 20-link base in distances not exceeding 60 or 80 chains, are very satisfactory. I would define good conditions thus: atmosphere temperature, 50° to 60° Fahr.; sky clouded; a clear, grey light, and gentle breeze blowing. Under those conditions, distances less than a mile can generally be determined within one five-hundreth of the true distance, and often much less. With a higher temperature and strong light, the error averages much more, and the distances deduced are short: with lower temperatures the distances long. The error in the distances deduced increases out of all proportion to the distances themselves; so that it does not follow that because we find an error of 10 or 20 links in a mile, that we will find twice that error in a two-mile distance. You will probably find the error increase in the ratio of the third or even fourth power of the ratio of increase in the distance. Why that is need not be discussed just now, as it would exceed the limits of a reasonable paper itself, and besides I am not quite clear as to why it is myself. If you have one of the ordinary forms of transit it will be well, as a check to the work of the miscrometer, to have a miscrometer head put on the tangent screw of the telescope, so that small vertical angles can be measured in that way. I had my four-inch D.L. pattern transit fitted that way at a very small cost, and, when using that instrument, always checked the micrometer work with it, and found the agreement between the two entirely independent methods very close. In practice it sometimes (owing to unfavourable background and the division of light in the Lugeol Micrometer) happens that the angle cannot be satisfactorily read with the latter instrument; in many of such cases the other arrangement enabled me to get over the difficulty, as with its single image there was no blending of unfavourable conditions. Whenever I could not satisfactorily, by one or the other instrument, determine the angle subtended by the base, I always left a base behind me from which I could deduce the distance from the succeeding station. This was done by setting up, in addition to the picket at the station, another one to the right or left of it, at right angles to the course to be measured and distance from the station 30, 40 or more links, as the ground would permit. From the succeeding station the angle subtended by this base was measured, and the distance deduced from it. Occasionally it would happen that there was no room for such a base; I would then, by a pre-arranged signal, let the base men know that I wanted them to erect such a base where they were, and I would measuse the angle subtended by it from my station. On my arrival at the following station I would measure the inclination of this base to the course it was intended to measure, and if found not at right angles to its length was reduced to its tangential length. It was sometimes found necessary to do this in the case of leaving a base behind. In order to facilitate as much as possible such cases, it is necessary that you have a good flag to signal with, and your base men have a good field-glass, or telescope, to see distinctly what you do signal. For a flag I used a piece of bleached cotton a yard wide and two yards long. It very seldom occurred that the signals made with this could not be distinctly seen. It is necessary that this be kept clean, or renewed occasionally, as a dirty one is not much use. Your base men should be thoroughly drilled in your code of signals before starting; otherwise you may have annoying misunderstandings and delay.

An amusing instance of this occurred the first day of my first micrometer survey. My flag was a small piece of red cloth, which worked all right the first four or five courses, none of which were a mile: then come one of a mile and three-fourths, in which I was in the shade of some large spruce. Do what I might, I could not make the base men understand I was through with them there. At last, in desperation, I pulled the cover off the canoe and waved it with all my might. This answered. In the evening I asked them what was the matter, and they innocently told me they could see nothing until I waved my pocket-handkerchief. Imagine their surprise when I told them the white handkerchief was the canoe-cover, a piece of cotton duck 17 feet long and 6 feet wide.

Each one can devise for himself his code, but I found the following work well:—The flag-pole held horizontally to the right, with the flag hanging perpendicularly from it, signified that it was ready for the base to be erected; when I was through, it was signalled by waving the flag across the line of sight high above the head. If the conditions for seeing and making a satisfactory measurement were not favourable, it was shown by waving the flag low in front of the observer; and, if I wished them to put up a base for me at their point, I immediately followed this by quickly waving the flag vertically on the left side of the signal man. Of course it was necessary for one of the men at the base to be on the look-out all the time they were at a station, for some time after the survey commenced; but experience soon taught them just what to expect and when to expect it.

My experience is that, with courses averaging a mile, on a down-stream survey about 20 miles per day can be made, and on an up-stream from 15 to 20. The greatest number of stations I set up in one day was 37, but that was an exceptionally long day. The greatest distance I have made in one day was 23¾ miles, and strangely enough that was on an up-stream work (on the Mackenzie). There were only twelve stations in it. The next greatest was going down the Athabsca, 23 miles, with, I think, about 18 stations in it. Had I plenty of time to do my work in, I would instruct my base men to confine themselves to distances of about a mile, as far as practicable; but when you have a long distance to go and a short time to do it in, with the certainty of a tiresome snowshoe tram of perhaps hundreds of miles if you are frozen they are very apt to think they have gone only a mile when they have gone upwards of two; and, though you expostulate with them, you are not very emphatic about it.

It should always be made a point to take along an instrument with which latitudes can be simply determined, and, during the course of the survey, as many latitudes as the weather will permit should be taken. If your transit is not fitted with a vertical arc of the requisite precision, a small reflecting circle and false horizon is convention and simple; and, by combining meridian altitudes of north and south stars, close and reliable results can be obtained.

To determine the latitude and longitude accurately of your principal point, you will require an astronomical transit. To determine latitudes with it, it will have to be set up in the "prime vertical"; or, better still, have a fine level attached to it on the principle of the zenith telescope. The stand for this instrument, in order to give it the necessary firmness, has to be made very heavy. This is a serious item for us. In order to overcome this, I had brass Y's made for the telescope I used, which are only a few pounds weight and answer just as well as the stand. A stump of a tree of the requisite size is selected, the middle portion cut out of it in the direction of the meridian, the Y's I have mentioned are then firmly screwed to the sides of the stump in such a position that the telescope when placed on them will revolve nearly in the meridian. It is finally adjusted in inclination and azimuth by the attachments to the Y's. When a suitable stump was not available, I have made a good stand by combining a couple of pieces of timber, 7 or 8 inches square and 8 or 10 feet long, in the form of the letter X; but with one part of it made much longer than the other. This was carefully and firmly planted in the ground in the direction, the Y's firmly screwed to the top of the timber and the final adjustment made as before. With this arrangement I am confident I have got as good results as with the regulation stand, and saved the transport of upwards of 200 pounes of rather bulky outfit. Before beginning to observe, a platform should be built around the stump or stand, above the ground, to prevent any vibration of the telescope in making the necessary movements around it.

In compiling your returns of survey, the latitude observations will show the errors of the micrometer work, and if a record is kept of the atmospheric conditions for each day, you can, with this data and the lengths of the courses, apportion the error in the intervals, so that there will be very little error in the final plot.

If you have only to make a track survey—that is, one in which the azimuths are taken with a compass and the distances inferred from the time taken to travel over them—your instrumental equipment need only be a reflecting circle or sextant, and a false horizon with a chronometer, or more than one if convenient. In conducting such a survey you should, as often as is possible, determine the magnetic inclination of the compass used, and as often as possible test the rate at which you travel. On such a survey it is essential that you observe, as often as possible, for latitude, by meridian altitudes of north and south stars; or, better still, circum-meridian altitudes of the same stars. For time and longitude, observe altitudes of stars east and west of the meridian, when near the prime vertical, and if possible not less than 30° above the horizon. By observing stars on both sides of your zenith, you eliminate the results of index error in your instrument. My experience is, you never know just what the index error of a sextant is; as I found it different in different atmospheric conditions. The reflecting circle I used last season, in ordinary summer temperature, was eccentric about 40″; but in the winter, in low temperatures, I found it nearly 3′.

Before starting on your survey, provide yourself with as many different maps of the district you are to pass through as you can. Very probably many of them are mere guesses based on hearsay, but they are valuable in that they show you what you may expect to find somewhere in your route. By combining them you can generally, though not always, map out your route and make your plans accordingly. You will generally find, however, that you have to go it blind, so to speak, until you enter the confines of your work; here you can learn from the natives the general character of your route, and the number and nature of obstacles in it. In this, however, as in every other human attribute, you will find many kinds and degrees of intelligence. Here, as in civilization, the greatest curse—to use a strong term—is the man who knows everything. You have but to ask him about a place or thing, and he immediately begins a tedious description of it, which generally has some truth in it, but in the main is imaginary. Get him to make a map and then note his remarks upon it, and, you will be disgusted with the general result. Possess your soul in patience; don't get prejudiced; get as many different maps from as many different men as you can, and in the end you can build a tolerably good one out of them all. You will also likely find that some one of them embodies the main features of all the rest. You can rely on the man who made that one. One striking feature of Indian maps is the general absence of all idea of scale; no two of them will delineate the same stream, for instance, anywhere nearly alike except by accident. It seems to me their conception of distance on their sketch is based on the time it has taken them to travel over the different parts; but I have found so many glaring exceptions to this that I do not give it as general. The best way—in fact the only way—to get an idea of distance from them, is to find the time it has taken them to travel over it, taking all possible care to learn the conditions at the time of travel; such as the time of the year, the state of the weather; whether they were travelling light or loaded; whether game was plenty or scarce; whether they had plenty to eat or were hungry—in fact, anything that would be likely to hurry or retard them on their march. Right in the way of the acquisition of this information comes in the general repugnance of the Indian to being questioned. If you could converse with him and had lots of time and means to entertain him sumptuously, you could get all the knowledge he is possessed of—probably more; but to start in cold blood and draw it out of him by a series of short, pointed questions, is contrary to his idea of the nature of things. The probabilities are that if you attempt to question him too much he will shut up altogether. Above all, avoid pointing out to him what you think is absurd or contradictory in his statement. Such is not "received with thanks" by him; and, if you do, you have very likely incurred his pity, if not his contempt. "What does a poor, ignorant white man know about these things?" Swallow all he gives you, and digest and assimilate all you can of it; but don't refuse anything or he will likely cut short the supply.

I have heard many amusing anecdotes of their contempt for whites who don't believe what they tell them; but they are too lengthy, and would be out of place here.

Another discordant feature in their map-making is the want of agreement as to the position of the general features in it with reference to the cardinal points of the compass. Very seldom will two of them independently agree on the direction of any distant point. Often I have marked the terminal points of a route I wished them to sketch in on a piece of paper, and held it in its proper position with reference to the meridian; but very seldom could they do it without turning the paper around to suit their idea of direction. It will be found that though they know the country well, they have not much capacity for conveying an intelligent description of it to a stranger, whatever they may do among themselves or with friends. If you employ any of them as guides, don't ask them too many questions about what is ahead if you wish to retain their good will and confidence; they seem to infer from it that you doubt their competency to guide you, and grow sulky. Don't be surprised if you find your guide, though he knows the route well, make many mistakes as to the time of arrival at different points on your route. It seems to me they generally build their time-table on the time or times it has taken them to go over the ground, and they don't realize for some time that they are travelling under different conditions. Don't be surprised if you find many guides among them like the Irish pilot who declared he knew every rock in the bay, and when the ship struck one exclaimed, "An' be jappers that one of 'em!" Very retentive memories are not more common with them than with others; and I have seen many of them who, to use a common phrase, get lost, and did not know as much about where they were as I did at the time—though very unwilling to admit it.

I would say to you emphatically: don't depend too much on them. Exercise all possible care and keep just as sharp a look-out as if you were without them; but be just as careful that they don't see that you distrust them. By consulting the officer in charge of the post or posts nearest to your route, you will generally be referred to some one fairly reliable, to whom you can apply for information or secure as a guide; but you will very often find that, just when you want them, the best men are engaged by the traders or missionaries. In obtaining information from them concerning country beyond your route, it is important to interview them several times, as very rarely do they give you all they know at one sitting, and it would be unreasonable to expect them to do so. Also, as far as you can, have such information confirmed or corrected by as many others as you can.

In getting names of places, it is important to learn from them why the names were given, and whether or not the name is merely local, or general. You will find many places have names which are merely local, and were given for some absurd or childish reason by some local character, and are only known as such by himself and a few others.

In descending streams, if you are making a micrometer survey, the rate of the current can be fairly well determined by sending your canoe into mid-stream in a calm day, putting your paddle two or three feet vertically into the water, with the blade across current, and timing yourself over the courses. By repeating this in different rates of currents, at frequent intervals, you soon learn to rate a current fairly well by looking at it. The same rate of current, however, has a different appearance in different depths of water, and with different bottom formations.

In descending rapids, even if you have a guide, it is well to take a good look at them before running them. This can be best done by getting as high above the river as possible; do this at several points so close together that you can have a good, clear view of the whole rapid on the side you intend to run on. From a height you can see better the whole surface of the water than when standing on shore; but you must always bear in mind that you will find the water much rougher when you are in it than it appears to be when looked down upon. When you are making this examination, if any place appears to you to be shallow, you can, if not too far out, sound it by throwing a three or four pound stone in such a way that it will decend vertically on the place you are doubtful about. If you hear distinctly the sharp blow of the stone on the bottom, it is unsafe—unless it is at the end of the rapid; if so, you can slow up on approaching it by holding your paddles or, better still, good, stiff poles firmly against the bottom, and then taking a safe time to cross the shallow. It is very important to know just where to enter bad places. To do this you have to know the set of the current. This you can ascertain, if it is not too far from you, by throwing in sticks and watching their drift and entry into the bad spot; a few trials will show you just where to drift and how to steer. When in very rough water, unless it is absolutely necessary to avoid danger, don't drive your canoe fast; if you do, she will ship water. If she were simply drifting with the current, she will go safely through places in which she might be swamped if driven at speed. When she is running she cuts into waves instead of riding them. Never turn sharply out of a swift current into an eddy; you are very apt to be upset if you do.

Don't forget, before you start on such an expedition, to provide every man in the party with a good life-preserver, capable of supporting at least 17 pounds, and as much more as you can get. The most convenient kind is made of india-rubber cloth, which you fill with air by blowing; but, as generally made, they are much too small, and only the largest size possess 17 pounds buoyancy. One of this buoyancy will keep a man, weighing about 180 pounds, head and neck out of the water without any exertion on his part; but when exerting himself he is much higher out of water. It is not enough, though, to enable him to help a companion or save property. The confidence which it gives a party, in any place into which they will venture, is worth much; they feel perfectly safe about themselves and don't loose their heads, as they otherwise might.

In ascending streams of more than three miles per hour current, the quickest and easiest way is tracking; that is, one of the party walking along the bank and hauling the canoe with a line. This line should be so attached that the canoe will keep out from the bank by the mere act of being hauled. The line need not be heavy: in ordinary current, a good, strong fishing line is strong enough, but in rapids you want a hard spun-line of at least one-eighth of an inch in diameter. One unaccustomed to it could hardly believe what steep inclines in a rapid such a line will haul a canoe up. If your line is heavy in easy water it curves and sinks in the water, thereby keeping the boat too close to the shore; it also catches on sunken sticks and stones, causing trouble and delay. In ascending a rapid in this way, there are only two ways in which accidents can happen: one is, the line breaking in a bad spot; the other is, putting the canoe into a rushing current out of an eddy too square with the current—to do so is to invite disaster. Your line may break, your canoe upset, or the water rush over her side and fill her. Enter her as nearly parallel with the current as you can, and keep your line tight while doing so, that there may be no undue strain on it when it does tighten.

To enable you to make your report as complete as possible, you should provide yourself with a good, self-registering thermometer, and the minimum temperature of every day should be noted; also the temperature at mid-day, or soon after. Also the temperature of the river water should be frequently noted. The latter is important to yourself in the fall, as indicating in a general way how much longer you will have open water. In clear open water a large stream cools very slowly, so that, if the temperature of the water is about 40 degrees, you may look forward to eight and ten days without ice; but if a heavy snow-fall comes on, start at once for the nearest post.

Also provide yourself with an aneroid barometer of good size, and before starting adjust it by a good mercurial to the proper reading; note its reading at least once a day. As soon as possible after your return, compare it again with a mercurial; if their is much difference, your knowledge of what it has gone through on the journey will help you to adjust the difference properly. In running down a river, if there is much fall you can, by reading it at frequent intervals—say every quarter or half hour, or at the head and foot of every steep part—arrive at a very close estimate of the ascent in that part of the river; but in ordinary currents it is practically useless. The use of the daily record is obvious. In the interest of science you should collect as many specimens of the fauna, flora and geology of the region you pass through as you can. Some of the specimens may have more than a scientific interest, for they may help to determine the general character of the country, or its general meterological conditions. I must say, however, if a surveyor attends to his own professional duties properly and fully, he has not very much time to attend to those matters; and very often when he sees some specimens that he would like to acquire, he is so situated and engaged that it is practically impossible for him to do so; yet, it is not out of his power to do something. All information you may get should be noted at once, with the date, place and name of party giving it, and any comments you may have to make on it, or conclusions to draw from it.

In conclusion I would say, aim at collecting all possible information, even if it is not pertinent to the object of your expedition, nor of a nature to be inserted in your report; you will probably find use for it some day, or it may be useful to someone else.

WM. OGILVIE.

ARE THE GREAT LAKES RETAINING THEIR ANCIENT LEVEL?

This question is not easy to answer definitely from past experience, because, as far as I am aware, there are no continuous records of the movement of lake waters, further back than thirty years. During this period, careful records have been kept, and the question would have been better put in the shape of—"Are the great lakes likely to maintain the mean level of the last thirty years?"—or it might have been put—"Have we any reason to fear the lakes are being slowly but surely drained?" I was led to make a few remarks on this subject because of the unprecedentedly low stage of water at the present time on all the lakes excepting Lake Superior. I have no theory to propound as to the future movement of the lake waters; my object has been simply to collect and give the Association what information I can upon the present and past condition of the inland seas, and invite opinion on the likelihood of their future movements.

Many of the members here present have read of the anxiety of ship-owners and vessel captains about the low stage of water last year, and there is little wonder at their alarm, when official records kept by the United States Government show that before the close of last navigation the water in Lake Huron was three and a-half feet lower than the level in June, 1886.

What no doubt increases the alarm is that this is not a sudden dip, but a steady fall of half a foot a year since 1886. All members of this Association know sufficient of marine matters to understand how seriously this action of the water may have affected the earnings of some of the splendid 3,000 ton steamers belonging to the States, trading from Lake Erie to Lake Superior, built in 1886, when the water had stood at a high and apparently permanent level for four years; vessels which when loaded were drawing all the water the canals and artificial channels could give them in the high stage of 1882 to 1886, all finding on their last trips in the fall of last year three and a-half feet less water; that is, if they made the trips at all, which they could only do with half cargo. To these men, Canadian ship-owners, and to lake commerce generally, the question of the maintenance of the lake level is a very important matter.

From records of the rain and snow fall kindly furnished me by Charles Carpmael, Esq., it appears that the diminished quantities of precipitation since 1886 is nearly equivalent to the amount the water has fallen below the mean level since that date. In Lake Superior the rain fall has been normal, and the level has not lowered like that of the other lakes.

Those well up on the subject of forestry will be able to say whether the clearing of the forests by fire and axe is likely to cause a permanent diminution of rain and snow.

Evaporation plays an important part in the lowering of the level of the lakes, no doubt, not merely from the sun's rays (which in the course of the survey my officers and myself have reason to feel hot enough at times), but by the dry westerly winds accompanying a bright sky and blowing with great force and evaporating effect when forming the dry rear semicircle of the revolving storms which pass over the lakes.

An alteration in the meteorological conditions to cause a preponderance of these winds in duration and force would no doubt have a marked effect on the water of the lakes.

The Welland Canal is an additional outlet for Lake Erie, the Sault Canal for Lake Superior, lower canals for River St. Lawrence, and the deepening of St. Clair River for Lake Huron. But I leave to hydraulic engineers to calculate the additional quantity of water carried off in this artificial way.

Another interesting calculation would be the wearing effect of continual running water at the various rapid outlets. It is *possible* that the rocky spots of these lakes are wearing deeper by this natural means.

It is not necessary to say much about the reported sub-aqueous and subterranean passage from Lake Huron to the Gulf of St. Lawrence, because it is probably of very ancient origin, and may be considered a constant factor affecting equally both sides of the equation—the future and the past. Should any member of the society have made a survey of this passage at any time a few words about it might be interesting. This tradition has some value, however, on account of its being handed down by seamen whose veracity on all matters maritime, we all know, has never yet been impugned.

In 1838, there seems to have been the highest stage of which we have any authentic record.

This high water has been used by the United States authorities as the plane of reference for their soundings on their charts and for the records of the oscillations to which I have alluded.

From 1859 to 1887 the mean water surface of Lake Ontario was two feet four inches below the high water of 1838; there has been on the whole a gradual fall from 1859 to 1872, and a similar rise to 1888. I have not the records from 1888 to date, but have reason to believe the fall has been similar to that on Lake Huron and Michigan, for which there are records to end of last year. In Lake Ontario during this period of twenty-eight years the water has fluctuated from eighteen inches above to the same distance below the mean level for that period The relationship between the rain fall and stage of water in this lake, however, is not very apparent. The yearly rise and fall ranges greater in this than any other lake, as much as four feet in 1867, the highest water taking place in May, and the lowest in mid-winter.

In Lake Erie the mean level from 1869 to 1887 is 2.1 feet below the high water of 1838; though the records are not printed to date there is every reason to believe that the water since 1887 has fallen similar to that of Lake Huron, for which we have records. There has been a gradual fall from 1859 to 1872, and a corresponding rise to 1887, but not so marked as in Lake Ontario. The fluctuations on either side of the mean line have not been so great as on Lake Ontario, nor has the yearly range exceeded one and three-quarters feet, excepting twice.

For Lakes Huron and Michigan the mean level from 1859 to 1887 is 2.8 below the high water of 1838. There was a period of low water from 1864 to 1869, again in 1872-3, also in 1879 and 1880. The water then rose steadily to 1886, and has fallen over three feet since, or to one and a-half feet below the mean level of 1859 to 1889. The average yearly fluctuation is about fifteen inches. In these two lakes the periods of high water have been attended by copious rain-falls, and *vice versa.*

For Lake Superior the mean level from 1859 to 1887 is given as three feet below the high water of 1838, and this level it has maintained to the present time very steadily; the relationship of the level to the rain-fall is not very evident here. The yearly rise and fall is about one foot.

On all the lakes, excepting Lake Superior, the period from 1881 to 1886 was attended by high water, it being during the principal summer months one foot higher than the mean from 1859 to 1887. This period was sufficiently long for men who had not studied the previously recorded movements of the waters to conclude that this stage of water was the normal condition, and quite accounts for the alarm of the ship-owners and masters who have had unpleasant reminders by the grounding of their vessels that the water has been steadily falling nearly half a foot yearly since 1886.

The water in Lake Ontario attains its maximum in May; Lake Erie, in June; Huron and Michigan, July and August; Lake Superior, in August and September.

The sudden fall of the water since 1886 was very noticeable on the steep shores of the vicinity of Parry Sound last year, the rocks being stained black and void of vegetation for two to two and a-half feet above the level of the present water. Admiral Bayfield in 1820 shows these as clean granite rocks just level with the water in that year. In 1887 these two rocks were in the same condition.

General Poe, U.S.A., the best authority, probably, on the hydrography of the inland seas, says in a letter to me:—"I cannot believe that the unprecedentedly low water in Lake Huron will continue, but I think the level will come up again as soon as the precipitation in the basins below Lake Superior has been below the mean, a fact which sufficiently explains the low stage we now have. Still, I am further of the opinion that the surface of the lakes has been at some time at a considerable lower level than that of which we have any record, and it is possible that the subsidence may continue until that lower stage is reached. That is, evidence exists to show that we are now in the highest stage of a series of fluctuations which have long periods, probably a century or two."

Mr. Carpmael, the Director of the Observatory at Toronto, says:—"As to whether the recent deficiency in rainfall is likely to be permanant, this is a question of great difficulty; it seems not unlikely, to a limited extent, it may be, owing to the diminution of the forests."

J. G. Boulton, R.N.

GEOGRAPHICAL NOMENCLATURE.

What's in a name? This question, if asked in relation to geographic names in this country would not until a few years ago have received more than a passing thought. It is true that many difficulties in regard to orthography—translation—transliteration, &c.—were met with by those engaged in the compilation of maps, and they had to be overcome in the best way that suggested itself at the moment, but of late years a growing want has been felt for some uniform and authoritative system of nomenclature.

In some countries attempts have been made to remove the difficulties referred to, systems have been adopted, and considerable progress has been made in nomenclature reform.

An effort has also been made to establish a universal system, and correspondence relating to this matter has been carried on between the Hydrographie officers of eighteen countries, in response to a circular issued from the United States Hydrographic office, the question of a general system being particularly interesting to hydrographers, as affecting sailing instructions and the preparation of charts.

It would not be possible to give, within the limits of one paper, an explanation of the various local systems which have been suggested or adopted by the Geographical Societies of different countries, or the details of the proposed general system. We shall no doubt have to conform to whatever system the majority of nations may decide to adopt, but at present what we are most interested in, and what is of great importance to us, is the acquirement of a system or means of dealing with the many discrepancies, duplications, &c., which exist in the geographic nomenclature of the Dominion, particularly in the northern and western portions of the country, and of providing suitable names whenever new ones are required. This question was, as you are aware, made the subject of a special report by the executive committee of this Association, which report was adopted at a general meeting and submitted to the Government recommending that effect be given to certain suggestions embodied in the report. The recommendation has been acted upon, and the work of revising the geographic nomenclature of the North-west has been commenced, some corrections in names have been authorized by the Department of the Interior and a number of duplicate names do not appear on recent maps. It is expected that suitable substitute names will be found for many of those which should be discarded, but as maps are now published by several of the Departments, it is difficult to secure uniformity in names, unless a map is published by one department and accepted as a standard by the others, as disagreements are likely to arise on points connected with the choice of names, orthography, &c., &c., for the settlement of which some means must be provided.

In the United States, attention was called to this subject by Prof.

T. C. Mendenhall, who soon after he was placed in charge of the United States Coast and Geodetic Surveys, noticed discrepancies in the geographic nomenclature on maps published by different departments, and even on different maps issued by the same department. He suggested to various officials engaged and interested in geographic work in the different departments, the holding of a meeting at which points of difference in geographic names could be discussed, and a satisfactory name and orthography agreed upon in each case and adopted for future use. These meetings were unofficial, and in order to render the results of the discussions authoritative, the matter was brought to the notice of the President, and he has appointed a Board to decide such questions. The Board is composed of officers of those Departments in which map making is carried on. They meet as occasion requires, and have already issued several bulletins of revised names.

To have a similar Board here is perhaps the only way in which we can readily and satisfactorily dispose of questions which will arise from time to time in connection with our work of revision, as what has been stated regarding the experience of the United States officials will apply to our own case.

Difficulties and discrepancies in questions of nomenclature generally proceed from the following causes; duplication of names, errors in orthography, errors in translation, corruption and misapplication of names, ignorance as to meaning, and carelessness in copying maps.

As regards duplicate names, or names of which there are families so to speak (for instance "Long Lake," "Pelican Lake," "Goose Lake," "Beaver Lake," "Beaver Creek," &c., &c.), it may be difficult to do away with some of them, but it is likely that in many cases, particularly in new parts of the country, a change of names will soon be accepted, and the eye of a person consulting a map will not, as now, take in at a single glance two or three features bearing the same name. Many of our North-western rivers have one name to where they fork, and then each fork or branch is really made a separate stream by carrying a different name, instead of bearing the parent name from its mouth to the source of its principal branch. We have "North Saskatchewan River," and "South Saskatchewan River," as far as the forks, then "Saskatchewan River" from there to the mouth. According to a map of the North-west, made by David Thompson in 1813-4 the southern part of the river—or south branch as I think it should be called—was known as the "Bow River." In my opinion a mistake was made by the change of appellation.

There are many errors in orthography which it is difficult, and in some cases almost impossible to correct, and the various spellings of the same name which is a frequent characteristic of our geographic nomenclature would seem to indicate the prevalence of ideas regarding the orthography of names, tending to remind one of Mr. Sam Weller's opinion, that the spelling of a name depended much upon the fancy of the speller.

Errors in translation may cause changes in names, and such errors may obtain a certain amount of stability from usage, as in the case of the errors in spelling, and corrections are not easily applied if the erroneous form has been retained for a considerable length of time. In Manitoba La Riviere Sale was Anglicised into "Stinking River." There is no reason that I am aware of why this incorrect and very objectionable term should have obtained usage so readily. Other similar cases might be mentioned.

There are also what appear to be misnomers, for instance w may find on a treeless prairie an elevation called "Poplar Hill." The traveller naturally asks, whence the name? Upon enquiry the fact will probably be elicited that a few poplar trees grew there at one time, but had been destroyed by prairie fires many years ago.

As regards actual misnomers, a number of other names in the North-west are unsuitable or have really no meaning. I noticed amongst memoranda dated 1807, by John McDonald of the North-west Company the following note: "I established a fort at the junction of the Red and Assiniboine Rivers and called it 'Gibraltar' though there was not a rock or stone within three miles."

There are some Indian names which when Anglicised would not be suitable for publication, and should not therefore be allowed to appear under the Indian disguise.

There are also English names which might be changed to advantage. Why the "Devil" should be allowed to retain proprietary rights in so many of our geographic features is a matter I think that requires to be looked into, for instance in the Rocky Mountains Park alone we find "Devil's Head," "Devil's Head Lake," "Devil's Gap," "Devil's Creek," and the existence on the maps of such names as "Stinking Lake," &c., &c., is antagonistic to the usually accepted theories regarding the purity and health-giving qualities pervading the climate of North-west Canada. "A rose by any other name will smell as sweet," and the lake or stream under a new name may retain its dirty color and unsavory odour, but of the thousands who have a map acquaintance with the feature, very few will ever chance to be within the seeing or smelling radius, or know that it had a name which was perhaps more suitable, but decidedly objectionable.

Names may by accident or want of care not indicate the features which they were intended to designate, and names of small features may cover too much space and thereby be more prominent than the features themselves. This in my opinion makes the use of long names, as applied to unimportant features very objectionable, and if the map is drawn to a very small scale some of them could hardly be shewn. I saw such a map so covered with names, many of which were long ones, that it really looked as if the usual order of things—viz., putting on the names last—had been reversed, and a sheet covered first with all the names that could be thought of, and the remaining available spaces filled in with topographical features.

Indian names with five or six syllables, where used to designate small features, are I think absurdly misapplied; a little creek or lake is sometimes dwarfed into insignificance by a cumbersome name containing twenty or thirty letters. Great care should be exercised in the future selection of names so as to secure brevity, euphony, phonetic pronunciation, and significant meaning; unpronounceable and otherwise objectionable names should not be perpetuated, they ought to be got rid of wherever it is possible to discard them.

"Hell Gate" (entrance to New York harbour) was formerly Hoellgat, that is "the whirling gut or strait," a much better name than the present objectionable corruption of it.

The appellation of a State or Province, and one of its towns, by the same name is somewhat confusing, for instance, New York State and New York City; Province of Quebec and City of Quebec.

A great many mistakes in names occur from misunderstanding on the part of explorers, and from information furnished by natives and half civilized people. It is said that a number of rivers in Africa are designated by words which are not their names, but only mean "water" or "river," and explorers have sometimes mistaken such words for the name of the rivers, etc. I am afraid that our nomenclature is not quite free from this fault.

Alternative names, and the use of the possessive case should, I think, be dispensed with wherever possible.

A well know German cartographer (Mr. Hermann Habernicht) in connection with his latest revision of the map of the United States, says: that in no part of the world are so many changes in the names of places required upon revised editions of maps, as in the newer parts of the Western Territories, where from the work of surveyors and explorers, the discoveries of pioneer settlers and miners, and other sources, information is being constantly collected and new data for maps secured. The same condition of things will be found in our North-western Territories, consequently our surveyors and explorers should interest themselves in this matter, and endeavour to procure all the information which they can respecting the names of geographical features in the localities covered by their operations.

With regard to a very important matter, viz., the teaching of geographical names in schools; there are very many names which the pupils had to commit to memory under old systems of instruction, and indeed at the present time there is very little modification of those burdensome methods which make the study of geography tiresome and uninteresting. The retention of names in the memory would be more easily and pleasantly accomplished if the meanings of the names and the interesting historical events connected with many of them were given to the pupils. Dr. Ganzenmüller—in a recent geographical publication—stated, that he had for several years directed his attention to this subject, and had become convinced that in teaching geography, simple explanations of geographical names would essentially aid the memories of pupils, lighten the teachers' tasks, and give a more lively interest to the whole subject. He believes, that the most repellant Chinese geographic names may be made intelligible in the following manner :—

The teacher first of all reminds his pupils that English monosyllabic words are frequently put together without change, for instance Newport, Capetown, Hartford, Oxford, Newcastle, Springfield, Deerfield, etc., then informing them that the Chinese have only monosyllabic words, and those are joined on the same principle. He then writes on the black-board in one line the words

Pe—North
Tong—East
Nan—South

and in another line

King—Capital
Hai—Sea

The pupils will then find by themselves that the northern capital is called Peking, and the southern capital Nanking, and if the teacher points on the map to the sea that bounds China on the east, his pupils will understand at once why it is called Tonghai, and that Nanhai is the name of the sea on the south boundary.

Names are often formed by combinations including words of former times, such as "Greenwich" or Green Village, "wich" being the old word for village; "Sandwich" Sandy Village, and "Norwich" Northern Village, and "folk" an old Anglo-Saxon word meaning people—gives "Norfolk"—northern people, "Suffolk" southern people.

Lessons on the other countries could be given on a similar system, and in this way many geographical names which were before nothing but unmeaning sounds will now through such explanations be found interesting. The English geographer, Mr. Ravenstein, mentions the fact of the compiler of a text-book boasting of "his" method, by which pupils are enabled to learn by heart 17,000 geographical names in the course of a few years. He thinks that knowledge of this kind, mechanically acquired, is a very evanescent possession; I quite agree with him in this opinion.

There appears to be no doubt that the system of teaching to which I have referred, will tend to facilitate and enliven the study of geography, and if by this means it is found that names are easily impressed on the memory, the system should commend itself to the consideration of teachers, with a view to its adoption in our schools.

I have dwelt at length on this part of the subject, for it seems to me that improved methods of teaching geography are tending towards the adoption of a universal system, and particularly in that branch of it which we are now considering. Cartographers will gladly welcome any advancement towards uniformity as it will greatly assist them in their work of map making which is now so beset with difficulty in the endeavour to reconcile the numerous discrepancies in data which appear on different maps of the same country.

There are other points which might be touched upon in connection with this subject, but to consider them now would occupy more time than could reasonably be allowed to one paper. I will therefore bring it to a close, hoping that ere long a substantial advance will have been made towards creating a system of nomenclature, and that the expression contained in the opening sentence of this paper will, in respect of our Geographic nomenclature, cease to be synonymous of a somewhat contemptuous indifference regarding the origin, orthography, and meaning of the words which designate so many important topographical features on our maps, but that there will rather be a lively interest taken in this work and a desire to know "what's in a name."

A. H. WHITCHER.

ARITHMOMETER.

Amongst the most remarkable applications hitherto made of machinery is perhaps that through which it has been used to relieve the scientific enquirer to a very great extent of the fatigue of manipulating figures, which consumes so much of his time and energies.

The use of the modern calculating machines relieves the mind and memory, and make the results reliable although the time consumed in making a calculation is shortened. The best computers are bound to make a certain percentage of error. The machine is equally bound to eliminate error.

The most ancient calculating machine known is the Chinese Souan-pan, which is in use in the Orient Empire. Those among us who have visited the Pacific Coast in British Columbia have seen it in any Chinese shop and on the counters of banks and exchange offices.

The Souan-pan is still used by Russians; it is a variety of the Roman Abacus, and across the Caucasian range is named Schtote.

Calculating machines may be divided into two classes.

The first-class would consist of instruments which can shorten and facilitate calculation, but require a certain amount of application of the mind and exerts the human intellect.

The machines of the second-class are called automatic, they are self-acting and do not require more from the operator than the strict knowledge of figures andnumeration.

CALCULATING INSTRUMENTS OF THE FIRST-CLASS.

Instruments of the first-class are very numerous, and were devised by men of nearly all countries from antiquity to date.

The Roman Abacus, the Souan-pan and the schtote already mentioned, are of this class.

The Bouclier-Compteur, a variety of the Roman Abacus is now introduced in the public schools in France.

The arithmoplanimeter of Leon Labanne, invented in 1839; the arithmograph of Gattey, invented in 1810; the arithmetograph of Dubois, invented in 1860, and several speedy calculators of American invention. These instruments are based on the principal of the slide rule. A slide rule and a calculator of this class of instruments is here exhibited.

The slide rule is a very convenient aid in rough calculation, but its use is very trying on the eyes. With the logarithmic rule here exhibited we can effect multiplication, division and proportion; find Latitudes and Departures in the quickest possible manner; solve directly cases of oblique triangles when one side and two adjacent angles are given and when two sides and an angle opposite one of them are given.

A scale of tangents, a scale of sines and a scale of equal parts are also added, from this last we are enabled to take the logarithm corresponding to any given number and make the converse operation.

The "calculator" here exhibited is of American make.

It is also a logarithmic scale, but the trigonometrical functions are not given.

In this the logarithmic scale is disposed on an helix drawn on the surface of a cylinder and is worked by the combined motion of the indices and the cylinder; this cylinder being hollow to allow of such motion on the surface of an inner cylinder.

CALCULATING MACHINES OF THE SECOND-CLASS.

The first machine of this class was invented in 1642, by Blaise Pascal, he was then in his 18th year of age.

The adding machine of Dr. Roth is an improvement on Pascal's machine; this first machine was designed to calculate the Louis-sous and deniers, and Dr. Roth made his for the decimal system.

Chs. Babbage made known his difference engine in 1822, by exhibiting a small model of it.

This engine, which is a marvel of human genius, was not intended to answer special questions, but to calculate and then print numerical tables, such as logarithm tables for the Nautical Almanac, etc.

The British Government advanced money, at different times, towards the construction of the invention of Babbage, but in 1834, after 12 years spent at its construction, only a portion was completed and already £17,000 had been advanced, although Babbage gave his personal superintendence without any remuneration.

While engaged in constructing the Difference machine, Mr. Babbage probably, through his increased experience of the capacities of machinery, was led to form a new conception, that namely, of the Analytical machine.

Babbage knew that if this last machine could be constructed, it would entirely supercede his first invention.

This was the cause that he did not press the completion of his first machine, and since the government saw no definit limit to the amount its completion would cost, the scheme was abandoned.

The Difference machine is now lying, an unfinished curiosity in the museum of King's College.

Before I touch upon the principal subject of my lecture, which is the "Arithmometer of Colmar," allow me to mention a few calculating machines of American and French make which were invented in recent years.

A very valuable calculating machine adapted to commercial and scientific computations is the "Comptometer," manufactured by Felt & Tarrant of Chicago.

This machine is worked by pressing on keys as is done in using the type writer. It shows best its superiosity in addition or subtraction.

RECENT FRENCH CALCULATING MACHINES.

La "Balance Arithmétique" et la "Balance Algébraique de Léon Lalanne" are machines of quite a different style; the first of these machines is adapted to perform the ordinary operations of Arithmetic while with the second we solve numerical equations of all degrees. Le "Tachylemme portatif" de Chambon is adopted to calulate interest on all sums from one franc to one million of francs and at any desired rate.

The "Arithmograph de Troncet," one of the small size of which has been exhibited at the Paris exhibition of 1889. The Arithmograph can be put in the pocket, being the size of a small port-folio, and with it addition and subtraction can be effectuated with a surprising rapidity, even in less time than it would take to write down the numbers to be added.

It can be used with great advantage for all the rules of Arithmetic and it would prove a great help and a sure control in calculating latitudes and departures when Boileau's table is used.

ARITHMOMETER OF THOMAS DE CALMAR.

Blaise Pascal had in fact discovered and used for his machine the principal which was employed by later mechanicians to produce what might be called a machine of high mechanical perfection and of great value to computers. Thomas de Calmar in 1818 was the first to produce a machine of such perfection over the rough machine of Pascal that he is called the inventor of the Arithmometer. The expositions of 1823-49-51 and the following have successively shown the Arithmometer of Thomas improved and simplified. Mr. Tate has made further improvements which makes it more durable and convenient in use. The Arithmometer now exhibited is the Thomas make. I now intend to make a few calculations to give you an idea of its working capacities, after which I will describe to you shortly how the mechanism acts and give you further notes as to its adaptation to special calculation.

Here the lecturer showed the machine's capacity for rapid and accurate work by making several calculations. Among these he found the product of 51,145,972 and 12,786,493 equal to 653,977,612,956,196 and the square root of this last number equal to 25,572,986, the whole of this operation lasted less than one minute.

How does it work?

The characteristic organ of the Arithmometer is the contrivance by which numbers indicated on the fixed plate are added to or subtracted from the product disks as many times as the motive handle makes complete revolutions. To effectuate which eight drums are mounted underneath the slots, and by the combination of bevelled gearing fixed to a shaft they all make a complete revolution while the motive handle makes a turn.

On a little over half of the circumference of these drums, are disposed nine successively decreasing cog teeth.

Above each drum is a pinion wheel containing ten teeth sliding on a square shaft and connected with a clutch with the markers above.

If the markers indicate 476 the first pinion wheel will revolve 6 teeth, the second 7, the third 4, corresponding to the number of cog teeth they meet in there position on their respective drums and by a new combination of a shaft and bevelled gearing, the numbers are reproduced in the product disks. But in order that the product disks show the sum or difference of several numbers, there must be a carrying apparatus. This mechanism has been the most difficult part to perform in order to ensure absence of error, and be simple in its parts.

It works in the second half of the revolution of the drums when the cog-wheels clutch with the markers are opposite the smooth part of the drums. When the interval between 9 and 0 is revolved under the holes of the product, cams carried by the disks meet a lever which cause a cog-wheel fixed on the shaft of the next order to be worked by a long tooth, specially placed for this purpose on the shaft of the order to be carried. A circular incline working against a stud, throws the tooth out of action after it has done its work.

On the upper part of the slide are 16 product holes, in those holes are registered sums, differences and the remainders of divisions; and on the lower part of the slide are 9 quotient holes in which are registered the number of turns made by the motive handle which marks the multiplicator, the quotients and the roots.

This register is not provided, as is the former, with a carrying apparatus. The product disks are numbered 0 to 9, and the quotient disks 0 to 9 and back to 0 again. A small hole is placed near each product and quotient holes in which is set in any required position small ivory pegs to mark the decimal points.

The studs near the holes allow one to set figures by hand.

ADAPTATION OF THE ARITHMOMETER TO PRACTICAL CALCULATIONS

Although the machine can be used for addition and subtraction, it is really valuable only when those two operations are combined or when several columns are to be added at once. The constant setting of the markers necessitated in these operations, consumes time and therefore unavoidable slowness.

Furthermore, attention must always be alive to control surely any error in the setting, and see that the regulator be in the wanted position.

It is in multiplication that the superiority of the machine is thrown in light from every standpoint; it is then quick in manipulation, free of all possible error and requires no exertion from the mind.

If in division the same divisor is common to several numbers as in reducing quantities from one unit to another, the reciprocal of the divisor can be taken and set on the fixed plate by the markers, and then the required numbers multiplied successively without any further setting required.

Division by the ordinary process is also very elegantly, quickly and safely performed in the manner already described. In division, the power of the machine is limited to 8 figures in the divisor, but has no limit either in the dividend or quotient. In multiplication, however, this machine can operate on 16 figures by 16, by using the formula $(a+b)(c+d)=ac+bc+ad+bd$, and keeping record of the operation and adding in their places the several products, and in fact, by an extension of this formula, the product of any two numbers can be found.

When no record of the operation is kept, the answer will be true to the first 12 places.

SQUARE AND CUBE ROOT.

The square root is extracted very elegantly on the machine, by using the known properties of arithmetical progression. We can extract the root directly for 7 or 8 first figures and then by division find 5 or 6 more figures correct to the last. A root extracted to 12 or 14 figures is surely enough for all purposes.

I owe to Mr. W. F. King, an analoguous method to extract the cube root, by which method we find directly the 3 or 4 first figures and then by division 8 more figures being found, we apply a correction to these 8 figures and in this way we can extract the cube root to 10 or 12 figures correct to the last.

The Arithmometer can be used with great advantage in performing proportion, discount, interest, exchange or percentage.

The fact, that this machine adds or subtracts a product at once, when operating makes its use superior to any other mode of calculation, when these operations are needed in the same problem, or for the final result of the same series of calculation.

Instances of these are verification of current accounts, taking by sections latitudes and departures of a long traverse, in certain numerical interpolation, etc.

As an example to this, the table of multiplication which was prepared by the order of the Minister of the French Navy and edited by Didot, could have been dictated with the Arithmometer much quicker than it could be written. The same could be said of Crelle's table and also for the calculation of tables of rate of prices, etc.

It is almost indispensible in preparing Ready Reckoners (Baremes).

In construction, computing the cubic contents, making estimates of every kind for statistic computation, etc. In reducing quantities from one unit to another, as yards to meters, dollars and cents to franks, etc., chains and links to miles.

With this machine, logarithms are no more necessary in solving triangles; natural functions of angles are used directly with ease.

Forms like the following are easily, conveniently and elegantly computed :—

$$\text{Sin a cos b} \times \text{sin b cos a}$$

$$\text{Cas a cos b} \times \text{sin a sin b}$$

$$\text{Sin } \tfrac{1}{2} \text{ A} = \frac{\text{versin a} - \text{versin (b} - \text{c)}}{\text{versin (b} + \text{c)} - \text{versin (b} - \text{c)}}$$

This machine is also very well adapted to form normal equations out of a series of observation equations and also to solve normal equations.

J. I. DUFRESNE.

MAPS AND MAP-MAKING.

I was asked by the President of this Association to give a paper on "Maps and Map-making," and I find that I am billed for one on the programme, but on getting to work at it I found it was too large an undertaking, it would require a good sized volume to do it justice, and besides that, there are some very good works on the subject which treat it very fully and efficiently. I have therefore confined myself to a few simple and practical points that may be useful to surveyors or others who are not good draughtsmen, but who sometimes have to make plans and want to turn out presentable ones.

I will first touch on drawing instruments. It is essential that they should be kept clean, pens and brushes particularly; they should always be cleaned immediately after use or they will soon be useless, a few pieces of cotton rag tacked on to the edge of the drawing board or table are convenient for this purpose. The drawing pen is troublesome, you want it to make a sharp clean regular line, if it is in good order it will do it but if not it won't, in the latter case if you look at it with a strong magnifying glass you will probably find one nib longer than the other, or that a piece has been chipped off the sharp end of one of them, if so screw the nibs together so as just to touch (it is very easy to spoil a drawing pen by screwing it up too tight), rub them down on fine stone until they are the same shape and length, then sharpen them until you can barely see the edge with a glass, being careful not to encroach on the length of either nib, it will then work all right.

Speaking of whetstones I find that the German hone is the most suitable for office use and it is a very necessary article in an office outfit.

Ordinary writing pens may be improved for special purposes in lettering and drawing by the use of the stone; for instance when a new "J" pen is used for making a broad line, it will make one with jagged edges, the reason of this is that the point is slightly rounded, and this can be remedied by rubbing it down until the point is cut off straight and at right angles to the line of the pen. Again, if you want to make a very crooked line of uniform thickness you will find it difficult to do so with a pen in its normal condition, but by taking a pen of suitable size, and shaping the point so that the width of it is equal to the thickness of the metal, and rounding the angles so that the point end presents a circular plane, you will find it quite possible to run it in any direction, backwards, forwards or sideways, and draw an even line all the time.

There are a few things besides those found in an ordinary case of instruments useful and time-saving; one of them is the road pencil or double-pointed pencil, it is particularly useful when you want to make a lot of letters or figures of the same size at different places on the plan;

you can draw parallel lines any where or in any direction retaining the required width without the trouble of measuring it off at each place.

Another thing is a border pen for making broad black lines, it saves the trouble of ruling double lines and filling in with a brush, which requires considerable time and care to make a good job of it.

Concerning scales, my experience is that boxwood is better than either ivory or vulcanite, ivory is very apt to warp edgewise thus curving the edge and destroying the accuracy of the graduation; vulcanite is very sensitive to changes of temperature. By the way, I might mention that a piece of Fabers ink eraser will clean a boxwood scale very satisfactorily. It sometimes happens that one wants some particular scale that one cannot procure just at the time; it is only the work of a few minutes to make any required graduation provided you have any scale at all to start with; the principul of the operation may be found in the 10th Prop. of the 6th Book of Euclid and the practice is better described by diagram; supposing you only have a scale graduated to 10ths of an inch and you require a scale of feet corresponding to 4 chains to an inch, that is 264 ft. to an inch. Near the edge of a sheet of good paper draw two lines parallel to it, mark a point A for the zero of your graduation and at any desired number of inches, say three inches, mark a point B, from there draw a line B, C, at right angles to the edge, in 3″ there would be 792 feet of the required scale. I suppose 10ft. would be as fine a division as would be required, that would make 79·2 divisions in the 3 inches: place the 10 scale so that zero is on the edge of the paper at A and 7·92 inches intersects B C, at C, tick off on A C whatever divisions are required, and with a ruler parallel to B C rule the graduations on A B from those on A C; of course it is not necessary to rule them the whole way, the lines drawn parallel to A B are to regulate the length of the lines marking the graduations, the nearer one for the 10 ft. and the other for the 100 ft., the 50 ft. may be a medium length.

I have often been asked how to mount a plan, so it may not be amiss to describe at least one good way here. Cut the cotton six inches larger each way than the paper to be mounted; provide youself with some good stiff wheat flour paste, a paste brush, a medium sized sponge and a bowl of clean water. Spread the cotton on a clean table or drawing board; be sure they are clean, for any stains of ink or watercolor that may be on them will stain the paper through to the surface; after spreading out the cotton dab it with the wet sponge until it sticks close to the wood, free from wrinkles and air bubbles; then sponge the paper with clean water until it is thoroughly soaked and quite limp; next squeeze the sponge, and remove any surplus moisture from the cotton that the sponge will absorb, then give the cotton a coat of paste, being particular to cover every part of it: remove surplus moisture from the paper and place it on the cotton leaving a margin of 3 inches of cotton all around it, go over the paper with the sponge so as to squeeze out any air that may be under it; after that turn up about an inch wide of the cotton all round, paste it and turn in down again, so as to stick it to the table; it will take from 12 to 24 hours for this to dry then trim the edges with a knife and straight edge before lifting it. This method avoids the use of tacks which are liable to draw the paper into scallops at the edge as it contracts in drying. It is not advisable to mount a manuscript map because the wetting of the paper causes the ink to run, but printed maps and lithographs can be soaked without damage; manuscript drawings on tracing paper may be mounted, because the paste has adhesion enough to hold the thin tracing paper without its being soaked, but great care is required to avoid blurring the lines of the drawing.

In plotting a survey, a traverse is generally the most troublesome part of it and the difficulty varies according to the manner in which the notes are kept, some give the angle of deflexion from one line to another, some the angle at each station contained between the lines; to facilitate the plotting it is necessary to reduce either of these to azimuth readings or else the bearings. The system most convenient to the draughtsman is the azimuth, it also facilitates the calculation of latitude and departure.

In plotting a traverse with a protractor, when the azimuths are given, a quick and accurate way is to draw a meridian at any convenient part of the map, place the protractor on it with zero to the North, put a weight on it to keep it in place and tick off the azimuth of a number of courses, say fifty, then turn the protractor half round, that is with zero to the South, and tick off the same lines again, thus each course is marked on opposite sides of the circle, which is a check on the work and also gives you a longer bearing for the direction of the lines; place the parallel rulers on each course thus marked and rule it off from its starting point, scaling the length of each as you go along. If the course of any line is such that the parallel rulers will not run from the circle to the required position of the line, place a straight-edge in position on the circle and run the parallel from it. Before using parallel rulers test their accuracy and if one wheel is too small, which is a common thing, gum a strip of paper around it until its diameter is equal to that of the other wheel.

The lettering on a map is generally the weak point of an amateur draughtsman; of course really good lettering is the result of training and constant practice, but rough lettering may be made very neatly and quickly by following a few simple rules; the letters should be uniform in size, and the heavy strokes should, as a rule, be parallel and equidistant. A very presentable plan can be made with only two kinds of lettering on it, namely, italics and block letters; for italics a Gillotts No. 303 pen is my favourite; for small block letters a Mitchells "J" is suitable, and for larger ones a flat brush cut square at the end. Make each part of a block letter with one stroke of the pen or brush as far as practicable, of course letters with curves in them require a little more manipulation. Block letters can be varied in style to a considerable extent, they may be perpendicular or sloping, tall and narrow, or short and broad.

When tracing on linen, the surface of it is sometimes greasy and will not take the ink well, that can be remedied by sifting a little pulverised chalk over it and rubbing it well in with a cotton rag. The dull side of tracing linen is the best to work on. If you should want to erase any ink from tracing linen do not use the knife, the rubber ink eraser is better. The use of a little chalk is beneficial on some kinds of drawing paper that do not take ink very readily, and it is indispensible on parchment.

In plotting exploratory surveys it is sometimes advisable to have a projection of the parallels of latitude and meridians of longitude. A simple conic projection is sufficient for a survey covering about 5° of Lat. and Long. To construct it, first draw a line A B down the middle of your paper for the mean longitude of the survey; draw another straight line C O D across the centre of the paper at right angles to A B; from this mark off points E F G, etc., in the curve of the mean latitude at any intervals you require, 10′ 30′ or one or more degrees; for this purpose a very complete table of co-ordinates. X and Y may be found in the United States Coast Survey Report of 1884. Connect the points E F G, etc., by chords and draw a meridian through each of them: the direction of any of these meridians may be found by intersecting arcs drawn with the same radius from adjacent points on each side of the required line; there are several ways of doing this more scientifically but this method is very simple and works well in practice. After drawing all the meridians required, measure off on each the divisions of latitude; the length of any such divisions can readily be obtained from the manual of Dominion Land Surveys. When the projection is drawn, plot in the survey from any known point, as you would any other traverse, only taking into consideration the convergence of meridians as you plot the bearings; and check on to any other known point. If it should be necessary to correct the traverse by distributing a correction for a cumulative error, an article which appears in the Michigan Engineers Annual, 1891, may be found useful.

The construction of the Gnomonic Projection, which is somewhat similar to the conic, was very lucidly described by Staff Commander Boulton, at our last meeting, and his paper is published in last year's report of this Association.

SEVERAL PROCESSES BY WHICH SURVEYORS CAN REPRODUCE THEIR PLANS.

Mr. Topley.—I will ask you to come round in order to examine the proofs made by the several processes. In the first place, I need not explain to you the process of the blue print, known as "Cyanitypes" or "blue prints," the formula of which is as follows:—

A.	Citrate of iron and ammonia	1½ oz
	Water	8 ozs
B.	Ferricyanide of potassium	1¼ oz
	Water	8 ozs

Mix well.

It is often the case when making a reproduction of fine drawings, the finer lines do not come out strongly enough. There is a simple method by which this can be remedied, by using a solution of carbonate of soda and drawing over the lines, which will leave the lines white and clear on the blue ground.

The next process, you will notice, is made something similar to the blue print, but by reversing the drawing and placing it on a piece of sensitized albumen paper, reversing the drawing to obtain a negative. Instead of its being white upon a blue ground similar to the blue process, it is white upon a deep brown, dense enough to resist the action of attenic light. From this negative here you will notice, an ordinary photograph with brown lines upon a white ground was produced. The formula for this process is as follows:—

Nitrate of silver	1 oz
Water	8 ozs
Nitrate of ammonia	½ oz

Acidulated with nitric acid, C. P.

The paper is then floated for 3 minutes and hung up to dry, after which it is placed upon the negative and printed until the lines are a dark brown on a white ground. Then it is placed, without washing, into a solution of hyposulphide of soda, composed of 1 oz. in 10 ozs. of water, and remains in the solution until it looks clear. This is a simple way of reproducing an ordinary photograph without the expense of chloride of gold, leaving the print bare white with brown lines.

The next process is done by taking the same negative and placing bromide paper face to face and exposed to a lamp or gas light from 10 to 25 seconds and developing with oxalate developer composed as follows:—

A. Oxalate of potash............ ....1 lb
Water................................48 ozs

Made acid with acetic acid.

B. Sulphate of iron.........................1 lb
Water........... ....32 ozs

Made slightly acid with acetic acid.

To use, mix 1 part of B to 6 parts of A. The print is immersed in water until it is soaked. The water is drawn off and the developer poured, and developed until the lines are black upon a white ground. Afterwards it is immersed in hyposulphide of soda, 1 oz. to 6 ozs. of water, until the unacted upon silver is dissolved, which will be known by the picture looking perfectly white with black lines. This method is one of the easiest and quickest, and yet one of the best for reproducing a drawing from the paper negative when a copy is required in a hurry.

The next process is photolithography. If small drawings are required to be reproduced in large numbers and as cheaply as possible, we would next resort to the photolithographic process. This same negative which I have shown you in the preceding processes, can be used, but instead of using the salts of silver we prepare a transfer which is made in the following manner:—Take a piece of this gelatinized paper, and immerse it in a solution of

Bi-chromate of potash.....................1 oz
Water.......... ....15 ozs
Liquid ammonia.............................1 oz
Alcohol.......................................4 ozs

At present the paper can be bought cheaply. After all the chemicals are thoroughly dissolved, immerse the paper in the solution for 3 minutes; then hang it up to dry in a deep yellow light. When thoroughly dry, this paper is placed in the same manner as in the last process, face to face, and the back portion of the negative exposed to the light until deep brown lines appear on the yellow ground. When all the drawing is distinctly seen upon the yellow ground, it is an indication that the drawing has been exposed long enough. Then the transfer as it is now called, is taken and rubbed over with a fat, greasy ink known as photo-lithographic transfer ink. It is then allowed to remain for from 10 to 20 minutes, until the grease has sufficiently soaked into the parts which have been acted upon by light; all portions which have been acted upon by light become insoluble. This is the reason the greasy ink takes upon that portion of the transfer. It is now placed in a water bath and allowed to remain until all the portions unacted upon by the light have absorbed water. It is then taken and placed upon a sheet of glass or upon a flat piece of board, and with a tuft of cotton or a soft sponge, the face of the transfer is gently rubbed over. Thus it will be seen that all portions, (if not over-exposed,) which have absorbed water, will resist the grease. The finished transfer should appear a lemon yellow with the lines of the drawing similar to those of an ordinary photographic print. This transfer is dried and then given to the lithographer, who transfers it to the lithographic stone. The lithographic stone is something similar to this transfer, as it absorbs water or grease readily; hence the value of this stone. The stone is made very clean and dry. The transfer is slightly damped and placed face downwards on the stone. The greasy parts of the transfer will be absorbed by the stone when put through the press. When the stone is wetted the lithographer passes a greasy roller with lithographic ink over the stone. The parts which have absorbed the grease on the stone will readily take the grease from the roller, thus bringing up the print in black and white upon the stone.

There are two other methods by which we can reproduce maps and plans without the aid of the camera, but these being the simplest I think it is only necessary to describe one.

One other way I might mention by which the surveyor can reproduce his own drawings without the aid of the photographer. The process is an old one called the "Papyrotype." It is done by simply immersing good strong paper in a solution of bi-chromate of ammonia and gum-arabic. After the transfer has been exposed under the negative, it is damped and placed upon a large sheet of zinc and allowed to remain there until dry, after which the block is exposed to the light, and the transfer lifted immediately, taking away from the zinc all the parts which have been acted upon by light, and leaving the gum which has been unacted upon remaining upon the zinc or stone. Next, oil is thoroughly poured upon the drawing, wiped off and allowed to remain long enough until the zinc or stone has absorbed a certain quantity of grease. Then this gum is carefully washed off and it is rolled up similarly to a lithographic stone. After the image or drawing has been well brought out upon the zinc, paper slightly damped, is placed upon the zinc plate and well backed with hard backing and simply run through a mangle, the pressure of course, being made to suit the thickness of your plate and backing.

Mr. Topley also exhibited samples of map work, photographs and photolithography, both fine and course work, as well as the above samples, which the members of the Association were very much interested in.

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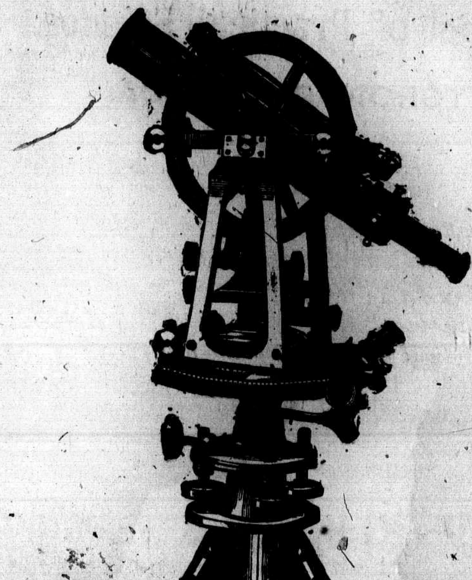

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