[For brief description see paper by J. F. Jackson on page 39.]

PROCEEDINGS OF THE Lake Superior Mining Institute SEVENTH ANNUAL MEETING

HOUGHTON, MICH.,

MARCH 5-9, 1901.

VOL. VII.

PUBLISHED BY THE INSTITUTE.

PRESS OF
IRON ORE,
ISHPEMING, MICH.

INDEX

PAPERS.

OFFICERS OF THE LAKE SUPERIOR MINING INSTITUTE, 1901.

PRESIDENT.

	Term Expires
W. J. OLCOTT,	1902

VICE-PRESIDENTS.

J. H. MCLEAN,	1902
M. M. DUNCAN,	1902
F. W. DENTON,	1902
WM. KELLY,	1903
N. P. HULST,	1903

MANAGERS.

J. B. COOPER,	1902
JAS. MCNAUGHTON,	1902
(One vacancy)	1902
JAS. CLANCEY,	1903
J. L. GREATSINGER,	1903

TREASURER.

GEO. H. ABEEL,	1902

SECRETARY.

A. J. YUNGBLUTH,	1902

(The above officers constitute the council.)

HONORARY MEMBERS.

Raphael Pumpelly, Newport, R.I. N. H. Winchell, Minneapolis.
T. B. Brooks, Newburg, N. Y.

ACTIVE MEMBERS.

Abeel, G. H., Hurley, Wis.
Adams, John Q., Negaunee, Mich.
Ahbe, F. R., Soudan, Minn.
Allen, W. J., Humboldt, Mich.
Alvar, Geo. A., Norway, Mich.
Ames, A. F., 5580 Canal St., Chicago, Ill.
Anderson, G. A., Commonwealth, Wis.
Appleby, Wm. R., Minneapolis, Minn.

Baer, Henry L., Hancock, Mich.
Baker, Fred J., Ishpeming, Mich.
Ball, Edwin, Birmingham, Ala.
Barber, S. S., Bessemer, Mich.
Barr, H. A., Escanaba, Mich.
Bayley, W. S., Waterville, Me.
Bayliss, Willard, Ironwood, Mich.
Beattie, S. T., Florence, Wis.
Begole, F. H., Marquette, Mich.
Bennett, R. M., Minneapolis, Minn. New York Building.
Bennett, S. E., Crystal Falls, Mich.
Bjork, Arvid, Crystal Falls, Mich.
Blackwell, Frank, Ely, Minn.
Bohman, Chas. E., Iron Mountain, Mich.
Botspord, Chas. W., Trimountain, Mich.
Brackenbury, Cyril, Hancock, Mich.
Bradt, E. F., Iron Mountain, Mich.
Brady, Samuel, Rockland, Mich.
Brady, S. Howard, Rockland, Mich.
Brandecker, Frank, Ironwood, Mich.
Breitung, Edward N., Marquette, Mich.
Brett, Henry, Calumet, Mich.
Brewster, Edward E., Iron Mountain, Mich.
Brigham, E. D., Chicago, Ill.
Brown, E. F., Iron Mountain, Mich.
Brown, Glenn Charles, Eveleth, Minn.
Brown, Wm. C, Box 14, Brooklyn, N. Y.
Browning, Richard C, Iron Mountain, Mich.
Coggin, F. G., Jr., Redridge, Mich.
Campbell, Duncan, Ishpeming, Mich.
Carbis, Frank, Iron Mountain, Mich.
Carbis, John, Iron Mountain, Mich.
Carey. John, 513 Rookery, Chicago, Ill.
Carmichael, Thos., Beacon, Mich.
Carter, R. B., 96 Lake St., Chicago, Ill.
Chadbourne, T. L., Houghton, Mich.
Chamberlain, Morrow, Chattanooga, Tenn.
Channing, J. Parke, 34 Park Place, New York City.
Chinn, Wm. P., McKinley, Minn.
Chynoweth, James, Calumet, Mich.
Clancey, James, Ishpeming, Mich.
Clark, Alonzo Webster, Jr., Eveleth, Minn.
Clarkson, Jas. F., 159 La Salle St., Chicago, Ill.
Clergue, Francis H., Sault Ste. Marie, Mich.
Coggin, F. G., Jr., Redridge,
Cole, T. F., Duluth, Minn.
Cole, W. A., Ironwood, Mich.
Cole, Wm. H., 117 E. Third St., Duluth, Minn.
Collick, Alfred, Ishpeming, Mich.
Collins, S. J., Milwaukee, Wis.
Conover, Abram B., 171 Lake St., Chicago, Ill.
Cooper, James B., So. Lake Linden. Mich.
Copeland, F., Vulcan Mich.
Coventry, F. L., Commonwealth, Wis.
Cowling, Nicholas, Ely, Minn.
Crowell, Benedict, Cleveland, Ohio.
Cundy, Jas. H., Quinnesec, Mich.
Cundy, Joseph J., Quinnesec, Mich.
Curry, Geo. A., Houghton, Mich.
Curry, S. S., Ironwood, Mich.

Dalton, H. G., Cleveland, Ohio.
Davidson, O. C, Commonwealth, Wis.
Dee, Jas. R., Houghton, Mich.
Dee, John B., Houghton, Mich.
Denton, F. W., Atlantic Mine, Mich.
Dickinson, E. S., Norway, Mich.
Drake, Frank, Ironwood, Mich.
Drake, Marcus M., Jr., Houghton, Mich.
Dubois, Howard W., 1527 N. 29th St., Philadelphia, Pa.
Duncan, John, Calumet, Mich.
Duncan, Murray M., Ishpeming, Mich.
Dunn, Bird W., Greenland, Mich.
Dunstan, Thos. B., Hancock, Mich.
Dyer, H. H., Biwabic, Minn.

Edwards, A. D., Atlantic Mine, Mich.
Ellard, H. F., Ironwood, Mich.
Elliott, Mark, Palmer, Mich.
Emmerton, F. A., Cleveland, Ohio.
Esselstyn, John N., Baker City, Oregon.
Elliott, S. R., Ironwood, Mich.

Fairbairn, C. T., Virginia Minn.
Fesing, Herman W., Calumet, Mich.
Findley, A. I., 27 Vincet, St, Cleveland, Ohio.
Fisher, H. D., Florence, Wis.
Fisher, James Jr., Laurium, Mich.
Fitch, Chas. H., Oak Park, Ill.
Fitch, Walter, Beacon, Mich.
Flewelling, A. L., Crystal Falls, Mich.
Flodine, Nels P., Marquette, Mich.
Floeter, Albert Henry, Redridge, Mich.
Formis, Andre, Ishpeming, Mich.
Frangquist, August, Crystal Falls, Mich.

Garberson, W. R,, Grand Pacific, Chicago, Ill.
Gardner, W. A., Chicago, Ill.
Gay, Joseph E., 11-13 William St., New York City.
Gibbs, George, Baltimore Locomotive Works, Philadelphia, Pa.
Gibson, Thoborn, Amasa, Mich.
Gilchrist, J. D., Sunrise, Wyoming.
Goldsworthy, Martin, Iron Mountain, Mich.
Goodsell, B. W., 33 So. Canal St., Chicago, Ill.
Goudie, Jas. H., Ironwood, Mich.
Grant. U. S., Minneapolis, Minn.
Greatsinger, J. L., Brooklyn N. Y.
Green, R. B., Two Harbors, Minn.
Green, Howard Jr., Marquette, Mich.

Haire, Norman W., Ironwood, Mich.
Hall, C. H., Evanston, Ill.
Hanna, L. C, Cleveland, Ohio.
Hardenburgh, L. M., Hurley, Wis.
Hardly, J. Wheeler, 11-13 William St., New York City.
Harper, Geo. Vance, Marquette, Mich.
Harris, S. B., Hancock, Mich.
Hartman, Frederick, Kearsarge P. O., Mich.
Haselton, H. S., Cleveland, Ohio.
Hayden, Geo., Ishpeming, Mich.
Hayden, Joseph M., Ishpeming, Mich.
Heath, Geo. L., So. Lake Linden, Mich.
Hellberg, Gustuf A., Norway, Mich.
Hendrick, C. E., Ishpeming, Mich.
Hillyer, V. S., Iron Mountain, Mich.
Hodge, Chas. J., Houghton, Mich.
Holland, James, Iron Mountain, Mich.
Honnold, W. L., 310 Pine St. San Francisco, Cal.

Hopkins, E. W., Commonwealth, Wis.
Horn, A. R., Milwaukee, Wis.
Houghton, Jacob, 51 E. Elizabeth St., Detroit, Mich.
Howe, Geo. C, Duluth, Minn.
Howe, John A., Duluth, Minn.
Hubbard, Lucius L., Houghton, Mich.
Hughes, C. W., Amasa, Mich.
Hulst, Nelson P., Milwaukee, Wis.
Hulst, Harry T., Houghton, Mich.
Hyde, Welcome, Appleton, Wis.

Jackson, J. F., Houghton, Mich
Johnson, Edward, Virginia, Minn.
Johnston, Wm. H., Ishpeming, Mich.
Jones, B. W., Vulcan, Mich.
Jones, Charles Colcock, Marquette, Mich.
Jones, J. T., Iron Mountain, Mich.
Jopling, J. E., Ishpeming, Mich.
Joyce, J. T. J., Eveleth, Minn.
Judson, F. A., Trenton, N. J.

Karkeet, J. H., Iron Mountain, Mich.
Kaufman, Louis G., Marquette, Mich.
Kellerschon, J., Ironwood, Mich.
Kelly, Wm., Vulcan, Mich.
Kent, Bamlet, Houghton, Mich.
Keys, Frank, Sparta, Minn.
Kidwell, Edgar, 207 Front St., San Francisco, Cal.
Kirkpatrick, J. Clark, Palmer, Mich.
Knight, R. C., Commonwealth, Wis.
Knox, John, Trimountain, Mich.
Koenig, George A., Houghton, Mich.
Krause, Chas. H., So. Lake Linden, Mich.
Kruse, Henry J., Beacon, Mich.

LaLonde, B. E., Ishpeming, Mich.
Lane, Alfred C, Lansing, Mich.
Lane, J. S., Akron, Ohio.
Larson, E. T., Ironwood, Mich.
Larsson, Per, Roros, Norway,
Lasier, Fred G., Iron
Hood, Ozni Porter, Houghton, Mich.

Leopold, Nathan F., 108 Dearborn Chicago.
Lewis, Hartwell T., North Tamarack, Calumet, Mich.
Linsley, W. B., Escanaba, Mich.
Longyear, J. M., Marquette, Mich.
Lord, A. W., Hancock, Mich.
Lord, Edward J., 825 B. St., Iron Mountain, Mich.
Luxmore, T. L., Iron Mountain, Mich.
Lynch, Thomas F., 1510 Old Colony Bldg. Chicago, Ill.

Maas, Arthur E., Negaunee, Mich.
MacNaughton, Jas., Calumet, Mich.
Manville, H. E., Milwaukee, Wis.
Manville, T. F., Milwaukee, Wis.
Marr, Geo. A., Houghton, Mich.
Mars, Wm. P., Duluth, Minn.
Martin, Thomas H., Ishpeming, Mich.
Mather, Wm. G., Cleveland, Ohio,
McCarthy, M., McKinley, Minn.
McComber, F. B., 19 So. Canal St., Chicago, Ill.
McDonald, D. B., Virginia. Minn.
McGee, M. B., Crystal Falls, Mich.
McKee, W. E., Ishpeming, Mich.
McKeever, R. T., Houghton, Mich.
McLean, J. H., Ironwood, Mich.
McNair, F. W., Houghton, Mich.
McNeil, E. D., Crystal Falls, Mich.
Michelson, Axel E., Duluth, Minn.
Miller, L. B., 39 Wade Building, Cleveland, Ohio.
Mills, F. P. Coulterville, Cal.
Mitchell, P., Aibbing, Minn.
Mixer, Chas. T. Ishpeming, Mich.
Monroe, W. G., Iron Mountain, Mich.
Moore, Carlton Franklin, Houghton, Mich.
Morgan, D. T., Republic, Mich.
Munroe, H. S. School of Mines, New York City.
Mountain,
Lathrop, J. H., Calumet, Mich.
Lawrence, Chas. E., Amaso, Mich.
Lawton, C. A., Depere, Wis.
Lawton, Nathan Oliver, Iron Belt, Wis.
Lee, Matt, Crystal Falls, Mich.

Orrison, J. Iron Mountain, Mich.
Osborn, O. S., Sault Ste. Marie, Mich.
Osborne, Nathan Sanford, Houghton, Mich.
Osgood, S. W., Jr., Copper Harbor, Mich.

Palmer, E. V., Mass City, Mich.
Parker, Richard A., Boston, Mass.
Parker, Wm, A., 509 Home Insurance Bldg., Chicago, Ill.
Parnall, S. A., Globe, Arizona.
Parnall, Wm. E., Jr., Calumet, Mich.
Paull, H. B., Globe, Arizona.
Peacock, Dan C, Commonwealth, Wis.
Pearce, Jas. H., Virginia, Minn.
Pengilly, John, Ely, Minn.
Penhallegon, Will J., Calumet, Mich.
Peterson, John O., Winona,Mich,
Peterson, Olaf G., Ishpeming, Mich.

Piper, James, Negaunee, Mich.
Pitkin, S. H., Akron, Ohio.
Platto, Frank, Ishpeming. Mich.
Pope, Graham, Houghton, Mich.
Prescott, P. M., Oregon, St., Milwaukee, Wis.
Pryor, John C., Houghton, Mich.
Pryor, Reginald C., Houghton, Mich.

Raht, Chas., 56 Pine St., New York.
Rattle, W. J., 807 Western Reserve Bldg., Cleveland, Ohio.
Redfern, J. A., Hibbing, Minn.
Rees, Allen P., Houghton, Mich.
Richards, Wm. J., Crystal Falls, Mich.
Roberts, C. T., Crystal Falls,
Newett, Geo. A., Ishpeming, Mich.
Nicholls, Frederick W., Houghton, Mich.

Olcott, W. J., Duluth, Minn.
Oliver, H. W., Pittsburgh, Pa.
O'Neil, F. W., Painesdale, Mich.

Sanders, M. S., Crystal Falls, Mich.
Savicki, Wm. Vaclav, Houghton, Mich.
Scadden, Frank, Crystal Falls, Mich.
Scott, Dunbar D., Houghton, Mich.
Seaman, A. E., Houghton, Mich.
Searles, E. C., Crystal Falls, Mich.
Senter, Albert W., So. Lake Linden, Mich.
Shephard, Amos, Iron Belt, Wis.
Sherlock, Thomas, Escanaba, Mich.
Shields, Jas. W., So. Lake Linden, Mich.
Shields, John C., Hancock, Mich.
Shields, Robert H., Arcadian, Mich.
Sjogren, S. A., Hjalmar Upsala Sweden.
Smith, Fred, Allouez, Mich.
Smith, Philip Sidney, Houghton, Mich.
Smith, Willard Joseph, Kearsarge, Mich.
Smyth, H. L., Cambridge, Mass.
Sperr, F. W., Houghton, Mich.
Stabler, O. F., Ironwood, Mich.
Stackhouse, Powell, Wallingford, Pa.
Stanton, F. McM., Atlantic Mine, Mich.
Stanton, John, 11 and 13 William St., New York City.
Stanton, John R., 11 and 13 William St., New York City.
Stephens, James, Ishpeming, Mich.
Stephens, Horace J., Houghton, Mich.
Streeter, Albert T., Calumet, Mich.
Sturtevant, H. B., Flat River, Mo.
Sutherland, D. E., Ironwood, Mich.
Sweeney, E. F., Virginia, Minn.
Swift, Geo. D., Duluth, Minn.

Mich.
Roberts, Enoch, Vulcan, Mich.
Roberts, E. S., Iron River, Mich.
Roberts, Harvey, Duluth, Minn.
Roberts, R., Negaunee, Mich.
Roscorla, N. B., Ironwood, Mich.
Rose, R. S., Cimarron, N. M.
Rothwell, H. G., care E. N. Breitung, Marquette, Mich.
Rough, Jas. H., Ishpeming, Mich.
Rundle, A. J., Iron Mountain, Mich.
Ryan, Edwin Patrick, Houghton, Mich.
Thompson, A. W., Vulcan, Mich.
Thompson, Jas. R., Ironwood, Mich.
Trebilcock, John, National, Mich.
Tregonning, Joseph, Ishpeming, Mich.
Trepanier, Henry, Iron Mountain, Mich.

Trestrail, Wm. M., Iron Mountain' Mich.
Truscott, Henry, Loretto, Mich.
Tweedy, R. B., Milwaukee, Wis.

Unzicker, Walter, Sparta, Minn.
Uren, Wm. J., Houghton. Mich.
VanDyke, John H., Milwaukee, Wis.
VanDyke, Wm. D., Milwaukee, Wis.
VanEvera, John R., Marquette, Mich.
VanMater, J. A., Elvins, St., Francois Co., Mo.
VanOrden Frank, Houghton, Mich.
VanOrden, Matthew, Houghton, Mich.
Vaughan, S. H., Houghton, Mich.
Vickers, J. M., Coulterville, Cal.
Walker, Elton W., Calumet, Mich.
Ward, E. T., 33 So. Canal St., Chicago, Ill.
Warren, Oscar P., Hibbing, Minn.
Warriner, S. D., Wilkebarre, Pa.
Wenstrom, Olof, Sulitjelma, Norway,
White, Peter, Marquette, Mich.
Whiting, S, B., Cambridge, Mass.
Wilcox, James, Arcadian, Mich.
Winchell, Horace V., Butte City, Mont.
Woodbridge, Dwight, Duluth, Minn.
Woodworth, Geo. L., Iron River, Mich.

Yungbluth, A. J., Ishpeming, Mich.

DECEASED MEMBERS.

Albert Conro. Edward Ryan. J. B. Lyons.

NOTE.—Members will please notify secretary of change of address.

LIST OF PAPERS PUBLISHED IN PRECEDING NUMBERS.

(For cost of previous volumes make application to the Secretary.)

RULES OF THE INSTITUTE

I.

OBJECTS.

The objects of the Lake Superior Mining Institute are to promote the arts and sciences connected with the economical production of the useful minerals and metals in the Lake Superior region, and the welfare of those employed in these industries, by means of meetings for social intercourse, by excursions, and by the reading and discussion of practical and professional papers, and to circulate, by means of publications among its members, the information thus obtained.

II.

MEMBERSHIP.

Any person interested in the objects of the Institute is eligible for membership.

Honorary members, not exceeding ten in number, may be admitted to all the privileges of regular members except to vote. They must be persons eminent in mining or science relating thereto.

III.

ELECTION OF MEMBERS.

Each person desirous of becoming a member shall be proposed by at least three members, approved by the council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the council may prescribe) upon receiving three-fourths of the votes cast. He shall become a member on the payment of his first annual dues, within ninety days of the notification of his election.

Each person proposed as an honorary member shall be recommended by at least ten members, approved by the council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the council may prescribe), on receiving nine-tenths of the votes cast.

IV.

WITHDRAWAL FROM MEMBERSHIP.

Upon the recommendation of the council, any member may be stricken from the list and denied the privilege of membership, by the vote of three-fourths of the members present at any regular meeting, due notice having been mailed in writing by the secretary to him.

V.

DUES.

The dues of members shall be five dollars, payable upon their election, and five dollars per annum thereafter, payable in advance at or before the annual meeting. Honorary members shall not be liable to dues. Any member not in arrears may become a life member by the payment of fifty dollars at one time, and shall not be liable thereafter to annual dues. Any member in arrears may, at the discretion of the council, be deprived of the receipt of publications or be stricken from the list of members when in arrears six months; PROVIDED, that he may be restored to membership by the council on the payment of all arrears, or by re-election after an interval of three years.

VI.

OFFICERS.

There shall be a president, five vice-presidents, five managers, a secretary and a treasurer, and these officers shall constitute the council.

VII.

TERM OF OFFICE.

The president, secretary and treasurer shall be elected for one year and the vice-presidents and managers for two years, except that at the first election two vice-presidents and three managers shall be elected for only one year. No president, vice-president or manager shall be eligible for immediate re-election to the same office at the expiration of the term for which he was elected. The term of office shall continue until the adjournment of the meeting at which their successors are elected.

Vacancies in the council, whether by death, resignation, or the failure for one year to attend the council meetings, or to perform the duties of the office, shall be filled by the appointment of the council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; PROVIDED, that such appointment shall not reader him ineligible at the next election^

VIII.

DUTIES OF OFFICERS.

All the affairs of the Institute shall be managed by the council, except the selection of the place of holding regular meetings.

The duties of all officers shall be such as usually pertain to their offices, or may be delegated to them by the council.

The council may in its discretion require bonds to be given by the treasurer, and may allow the secretary such compensation for his services as they deem proper.

At each annual meeting the council shall make a report of proceedings to the Institute, together with a financial statement.

Five members of the council shall constitute a quorum; but the council may appoint an executive committee, or business may be transacted at a regular called meeting of the council, at which less than a quorum is present, subject to the approval of a majority of the council, subsequently given in writing to the secretary and recorded by him with the minutes.

There shall be a meeting of the council at every regular meeting of the Institute and at such other times as the/y determine.

IX.

ELECTION OF OFFICERS.

Any five members, not in arrears, may nominate and present to the secretary over their signatures, at least thirty days before the annual meeting, the names of such candidates as they may select for offices falling under the rules. The council, or a committee thereof duly authorized for the purpose, may also make similar nominations. The assent of the nominees shall have been secured in all cases.

Not less than two weeks prior to the annual meeting, the secretary shall mail to all members not in arrears a list of all nominations made, and the number of officers to be voted for in the form of a letter ballot. Each member may vote either by striking from or adding to the names upon the list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing the ballot with his name, and either mailing it to the secretary, or presenting it in person at the annual meeting.

In case nominations are not made thirty days prior to the date of the annual meeting for all the offices becoming vacant under the rules, nominations for such offices may be made at the said meeting by five members not in arrears, and an election held by written or printed ballot.

The ballots in either case shall be received and examined by three tellers appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected. The ballots shall be destroyed, and a list of the elected officers, certified by the tellers, shall be preserved by the secretary.

X.

MEETINGS.

The annual meeting- of the Institute shall be held on the third Tuesday of August in each year. The Institute may at a regular meeting- select the place for holding the next regular meeting. If no place is selected by the Institute it shall be done by the council.

Special meetings may be called whenever the council may see fit; and the secretary shall call a special meeting at the written request of twenty or more members. No other business shall be transacted at a special meeting than that for which it was called.

Notices of all meetings shall be mailed to all members, at least thirty days in advance, with a statement of the business to be transacted, papers to be read, topics for discussion and excursions proposed.

No vote shall be taken at any meeting on any question not pertaining to the business of conducting the Institute.

Every question that shall properly come before any meeting of the Institute, shall be decided, unless otherwise provided for in these rules, by the votes of a majority of the members then present.

Any member may introduce a stranger to any regular meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

XI.

PAPERS AND PUBLICATIONS.

Any member may read a paper at any regular meeting of the Institute, provided the same shall have been submitted to and approved by the council, or a committee duly authorized by it for that purpose prior to such meeting. All papers shall become the property of the Institute on their acceptance, and with the discussion thereon, shall subsequently be published for distribution. The number, form and distribution of all publications shall be under the control of the council.

The Institute is not, as a body, responsible for the statements of facts or opinions advanced in papers or discussions at its meetings, and it is understood, that papers and discussions should not include personalities, or matters relating to politics, or purely to trade.

XII.

AMENDMENTS.

These rules may be amended by a two-thirds vote taken by letter ballot in the same manner as is provided for the election of officers by letter ballot, PROVIDED, that written notice of the proposed amendment shall have been given at a previous meeting.

MINUTES OF THE SEVENTH ANNUAL MEETING

HELD IN THE COPPER DISTRICT WITH HEADQUARTERS AT HOUGHTON, MICH.,

March 5th, 6th, 7th and 8th, 1901.

TUESDAY, MARCH 5th.

Members of the Institute and their guests began to arrive on the noon train, a number following on the evening trains. The visitors were met at the depot and taken in charge by a delegation of the copper country members and escorted to the hotel. The arrangements made by the local members for the comfort of the visitors during their stay were most perfect in every detail, comfortable rooms having been provided for all.

After dinner the party was taken by street cars to the Quincy mine, where they were met by S. B. Harris, General Superintendent, J. L. Harris, Ass't Superintendent, Thomas Whittle, Mining Captain, and James Moore, Master Mechanic. Owing to the very severe storm during the afternoon, only a portion of the mine was visited. The first being the compressor and boiler plant at No. 6 of the "North Quincy," formerly the Pewabic. The compressor is of the Allis type, compound condensing engine 30"x60" and 54"x60" cylinders with 30"x60" air cylinders. The boiler plant consists of twelve horizontal-return tubular boilers of the Roberts pattern and are of 125 H. P. each. Next the party was taken to No. 2. The compressors here are of the Rand type and consist of two cross-compound 2-stage Corliss condensing engines with cylinders 22"x48" and 40"x48" with air cylinders 39"x48" and 25"x48", the capacity of each being 4320 cu. ft. of free air per minute at the nominal speed of 65 revolutions. The boiler plant consists of four vertical Wickes water tube boilers of 250 H. P. each carrying 125 lbs. of steam.

From here the party visited the spacious shop buildings. These are new, having been built during the past year and equipped with modern machinery throughout. The buildings are high, giving the best ventilation possible and are well lighted and cleanly. The machine shop is built of brick and steel, and the blacksmith shop of stone. Concluding the inspection here, the party proceeded to the "South Quincy" and visited No. 2 Hoist, No. 7 Combined shaft and rock house, and No. 7 Hoist. No. 2 Hoist is of the Allis-Corliss pattern, direct-acting, with cylinders 48"x84", and drum 26 ft. diameter and 13'2" face. The capacity of the skip is 6 tons.

No. 7 shaft house went into commission in the fall of 1900. It is built entirely of steel and was erected by the Wisconsin Bridge and Iron Co. The rock breakers, steam hammer, etc., are driven by a Bates engine 14"x36". No. 7 Hoist is similar to No. 2, though larger, the cylinders being 52"x84". The drums are 28 ft. in diameter by 11'9" face with capacity for 8000 ft. of 14" rope. The engine is equipped with steam reverse gear and speed regulator of the fly ball type, and is at present adjusted to 3,000 ft. per minute. The brake is of the steam gravity type with two bands.

The delegates were much interested in the visit through the Quincy notwithstanding the severe storm, and after getting down the hill, the cars were again boarded and proceeded to Houghton, where the Michigan College of Mines was visited. Owing to the late hour, only a hasty inspection of the several buildings could be made. The work of this school is directed solely towards the training of mining engineers, and the equipment is therefore very complete along the lines of geology, chemistry and engineering. A large main building houses the departments of geology and chemistry, besides class rooms, a large technical library, general offices, and physical laboratories. A great deal of laboratory work is done in connection with nearly every subject and collections are extensive and in some lines unequalled. A well-equipped assay laboratory is in a separate building. The mechanical engineering building contains shops and testing laboratories for the department of mechanical engineering, and also furnishes quarters for the mining engineering work.

An ore-dressing building is one of a number of small temporary structures on the grounds. Of the 153 graduates of the institution, over 98% are engaged in some phase of mining. Such a record testifies to the thorough work done by this institution.

EVENING SESSION.

At 8 p. m. the meeting at the Armory was called to order by President Graham Pope. There was a large delegation present, some members being accompanied by ladies, who manifested much interest in the proceedings. The President's address, "Some Early Mining Days at Portage Lake," was then delivered. This presented some very interesting history heretofore unpublished. Mr. Pope's address was followed by a paper on "Steel Construction for Mines," by Mr. J. P. Jackson. The last paper for the evening was an "Historical Sketch of Smelting and Refining Lake Copper" by Mr. J. B, Cooper.

On motion the President appointed the following committees:

Auditing Committee—Edwin Ball, J. M. Longyear and J. H. McLean.

Nominating Committee—Geo. B. Abeel, Geo. D. Swift, Jas. Clancey, F. W. Denton and Wm. Kelly. Mr. Kelly being unable to be present, Walter Fitch was appointed his successor. Meeting then adjourned.

WEDNESDAY, MARCH 6th,

At 9:00 a. m. the party, numbering 175, took a special train provided by the Copper Range R. R. Co., for Redridge, where the new dam for the Atlantic-Baltic Companies is being built. Work on the dam had been stopped, owing to the winter, so that only a portion of it could be seen above the snow and ice. This dam is considered a feature in hydraulic engineering and will be carefully watched by engineers throughout the country. The main structure or dam is about 475 ft. long and 74 ft. high in the central or deepest section, with wings on the east of 350 ft. and on the west of 200 ft. This from its form of construction is known as a gravity dam, and is built of concrete and steel.

From here the party visited the Baltic mill, then in course of construction. This mill is being built of steel and is about 175x200 in size.

The Atlantic mill was next visited, where 6 stamps are in operation. The party received much information on construction work and points of interest from Messrs. Denton, Jackson and Clarkson.

Again taking the train, the next stop was at Painsedale, where lunch was served at a large boarding-house of the Champion mine. Dr. Hubbard and his staff receiving the blessings of 175 of the hungriest men ever assembled together. It was rumored that more than 1,000 sandwiches were devoured. After lunch the various shafts of the Champion mine were visited under the escort of Dr. L. L. Hubbard, Engineer O'Neil and Clerk Harrington. Work on this property was begun in 1899 and tour shafts are now being worked. Considerable surface work has already been done in the erection of substantial buildings and dwellings for the employes. Contracts have been made for the shaft and rock houses. The site for the mill will be opposite that of the Trimountain on Lake Superior.

From here the party next visited the Trimountain property, being received by Supt. James Chynoweth. This, like the Champion, is one of the favorites of the copper district. Work was commenced in the early spring of 1899 and while some delay was experienced at the start, owing to the great depth of sand overlying the ledge, yet considerable progress has been made. Shafts are being sunk. The buildings and machinery so far installed are of ample size and new ones are being erected as necessity requires. There were never more industrious "miners" at work on a rock pile than were the delegates trying to break off pieces of mass copper for souvenirs.

Again boarding the train, the party was taken to the Baltic mine. This property was known for several years as the "Six Mile Hill," and attained considerable reputation by the explorations conducted by Capt. W. A. Dunn. It is now classed among the producers, having for some time treated its rock at the Atlantic Mill, with which property it is closely indentified. The Baltic has the distinction of being the first mine opened on the "South Range."

The Atlantic was next visited, and owing to the late hour, Mr. Frank McM. Stanton provided sleighs that the party might cover the ground before dusk. The new hoisting plant at "B" shaft was, one of the many points visited. This is the Fraser & Chalmers type with double conical drum, the dimensions being 12 ft. at each end and 24'4" in the center, where there is a cylinderical section 18" wide. It is operated in counter balance and has a capacity for 4,000 ft. depth. The product of the mine is hauled to the mill over its own road which also takes the product from the Baltic mine. From here the party took the train for Houghton.

EVENING SESSION.

At 8 p. m. the second evening session convened at the Armory, where the meeting was called to order by President Pope. The first paper read was on "No. 5 Shaft at the Tamarack Mine" by Mr. W. E. Parnall, Jr. This was illustrated by a model of the head frame, also drawings of plan of shaft timbering and cross section of the shaft from surface to the Calumet Conglomerate, which are published in this volume. This was followed by two papers from Dr. Geo. A. Koenig of the Michigan College of Mines. The first "The Cause In the Inaccuracy of the Volumetric Copper Determination," the second "The Crystallization of Mohawkite, Domeykite and Other Similar Arsenides."

The last paper of the evening was by Geo. L. Heath on "The Testing and Control of the Product in Modern Copper Refineries." The meeting then took up the order of business.

The Nominating Committe presented the following list of officers for the ensuing term:

President, W. J. Olcott, of the Lake Superior Consolidated Mining Co.

Vice-Presidents, Wm. Kelly, of the Penn Iron Co., Dr. N. P. Hulst, of the Oliver Iron Co.

Managers, Jas. Clancey, Lake Superior Iron Co.. Jas. MacNaughton, National Steel Co., J. L. Greatsinger, Duluth & Iron Range R. R. Co.

Treasurer, Geo. H. Abeel, Montreal Mining Co.

Secretary, A. J. Yungbluth, The Cleveland-Cliffs Iron Co.

The report of the committee wason motion adopted and the officers chosen were declared elected by the unanimous vote of the meeting. The newly-elected president was escorted to the stage and presented with the gavel of authority by Graham Pope in a neat little speech. The gavel was made of copper and iron, representing the two mining branches of which the membership of the Institute is composed. Mr. Olcott in a few well chosen words, thanked the members for the honor conferred on him, and said that he felt proud to represent an Institution, the membership of which was composed of so many of the prominent men in the mining industry, and where such harmony prevailed as in this organization, The meeting then adjourned.

THURSDAY, MARCH 7th.

At 9:00 o'clock the party left by special train over the Mineral Range R. R. for Calumet. Sleighs were provided and under the escort of Captains W. E. Parnall, John Duncan, Jas. Ramsey and W. E. Parnall, Jr., the various places of interest were visited. The first stop was made at the Tamarack No. 5 shaft and steel rock house. The sinking of this shaft was made the subject of the paper presented by W. E. Parnall, Jr., and much interest was manifested in inspecting the plant. As the paper so fully explains all points of this shaft, we will not enter upon further description here. The steel rock house, the second largest in the district, is nearing completion and will stand foremost in point of equipment. The hoisting plant at No. 5 is of the Nordberg pattern, there being four high pressure cylinders each 34"x72" connected direct to drum shaft. From No. 5 the party drove to No. 3 or North Tamarack. The hoisting plant at this shaft is of the Allis pattern and was installed during 1895 and 1896. The drums are conical at each end with a diameter of 13 ft. at the ends and 38 ft. in the center.

Leaving the Tamarack the next stop was at the Red Jacket shaft of the Calumet and Hecla. This is the deepest shaft in the world, being nearly 5,000 ft. vertical, has six compartments, and required nearly ten years to sink. The hoisting plant is of enormous capacity, made necessary by the great depth and the large output to be handled. This is known as the Whiting system, being two tandem driven pulleys instead of drums and working in balance. The steel rock house at this shaft is the largest structure of its kind in the world.

From here the party went to the Armory, where luncheon was served. Being thus refreshed, the tour of inspection was again resumed. As there were so many points to be visited, no time was lost and the arrangements for covering the ground thoroughly were most complete in every detail. The first stop was made at No. 5 which is the northermost shaft of the company. The next stop was at the superior engine house. Here the party found much of interest and considerable time was spent in looking over the enormous machinery in operation. The "Superior" engine has a capacity of 4,700 H. P., with the "Baraga" and "Rockland" as auxiliary engines. The giant engine "Mackinac" of quadruple cylinder type, triple expansion, has a capacitv of 7,000 H. P. Two enormous Rand Compressors are also housed in this building. The shops, which are among the most complete in the country, were next visited, also the Hancock and Pewabic engine houses.

En route to the train, a visit was made to the library building. This is a monument of the public spirit of the management of the Calumet and Hecla Co. Here are found the choicest volumes of ancient and modern literature, containing in all upward of 25,000 books, including all modern languages. This library is for the use of the employes and is well patronized.

This concluded the tour of inspection for the day, and again boarding the sleighs, the party was taken to the train for their return to Houghton.

EVENING SESSION.

At 7:30 p. m. a meeting of the Council was held to dispose of some preliminary matters. At 8 p. m. President Pope called the regular meeting to order. The report of the Auditing Committee was then read and on vote accepted and the committee discharged. The report of the council on applicants for membership was read and was unanimously approved by vote of the meeting and the applicants duly elected.

The first paper for the evening was by Mr. John A. Redfern on the "Cross Compound Pumping Engine in the Penobscot Mine." This was followed by a paper by Mr. O. P. Hood on "The Invasion of the Water Tube Boiler Into the Copper Country," another by Mr. Walter Fitch on "A New Form of Mine Drill Bit," and one by Mr. F. W. McNair, president of the Michigan College of Mines, on "A College View of the Mining Graduate." The concluding paper was by Dr. L. L. Hubbard on "A Plea for Accurate Maps."

Following the reading of papers the Secretary presented invitations from Mayor Rose and the Citizens' Business League of Milwaukee, asking the Institute to hold its next annual meeting in that city. Motion made and seconded that the Institute tender a vote of thanks and appreciation to Mayor Rose and R. B. Watrous, Secretary, for their kind invitation to meet in Milwaukee, and that the decision of the matter be referred to the council for such action as in its judgment may be deemed advisable. The motion was carried.

The Secretary read a letter from Mr. B. W. Goodsell regarding the International Mining Congress to convene at Boise City, Idaho, on July 21st. Motion made and seconded that the communication be received with thanks to Mr. Goodsell and placed on file. The motion was carried.

Mr. Denton:—As this will be the last business meeting of the Institute, although not the last session, I would like to take this opportunity to move that a vote of thanks be tendered the Electric Street Railway Company, the Mineral Range Railway Company, the Hancock & Calumet Railway Company and the Copper Range Railway Company, for their kindness in furnishing us with special transportation free of all expense to the Institute." The motion was supported by Mr. Fitch and carried.

Mr. Fitch:—"As this seems to be the close of the business exercises of this Institute, it would be quite becoming and the duty of this Institute to extend, and I move a resolution that the vote of this Institute be extended to our President, Mr. Graham Pope, for his services as President during the past year and for the very excellent work that he has done for it and for the magnificent treatment that he has secured for us on this visit. Also that the thanks of this Institute be extended to Professor Sperr for his services as Secretary, and also that the thanks of the Institute be extended to the different mine managers and officers who have so ably seconded your efforts in entertaining; us on this splendid trip."

Mr. Denton:—"I know that the President is bashful about calling for a second to such a motion; I therefore second it. You have all heard this vote of thanks to our President and to the others who have assisted in the arrangements, and I will put the motion before you." The motion was unanimously carried, to which Mr. Pope responded:

Gentlemen,—It would be simply a discourtesy to pass over this resolution without notice. I wish to say, what I said to Mr. Fitch today, that I took upon myself with great reluctance the duties of President of this Institute, thinking someone else could render greater service, but that it was with equally great reluctance that I should lay down my office now. If I have been successful in serving you, it is a matter to me of great personal thankfulness. From the members of the Institute I have always received the most kindly treatment and therefore I was glad to have the opportunity to repay in some measure the courtesy and kindness extended to me. I have done my best to make your visit successful, but I could have done but little without the earnest interest and help of our people and the local members of the Council. When making arrangements for your visits to the different locations, the managers of the mines not only received me courteously and kindly, but with eager willingness, and said they would do all that was possible for them to do. The managers of the various railway companies received my applications in the same spirit. What you have seen in this district you will not forget. What has been done for you by your mining friends here I know will remain in your memory as something done cheerfully for your advantage, pleasure and satisfaction. I thank you, gentlemen."

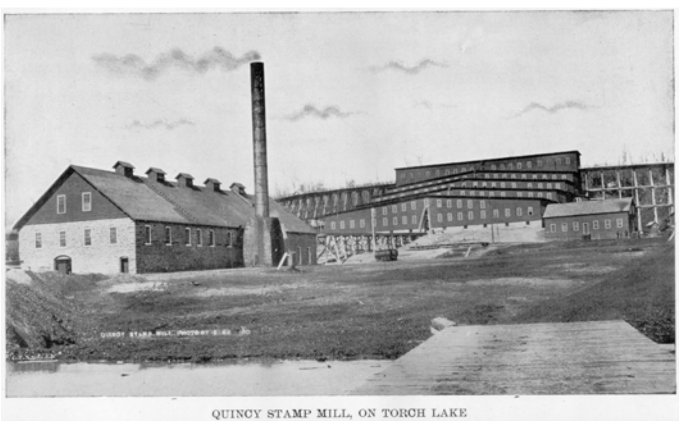
This closed the transactions of the seventh annual meeting, one of the most successful yet held by the Institute.

FRIDAY, MARCH 8th.

At 9 o'clock a. m. the party left on the special provided by the Mineral Range railroad to visit the Calumet & Hecla smelting works, the Tamarack and Quincy stamp mills, and the Tamarack-Osceola copper manufacturing plants at Dollar Bay.

The first stop was made at the Calumet & Hecla smelting works at Lake Linden, Mr. James B. Cooper, Superintendent, taking the party in charge. The various buildings of this plant were visited. After completing the inspection and just before leaving, Mr. Cooper presented each member with a neat souvenir in the shape of a small copper ingot.

From here the party took the train back, stopping at the new Tamarack mill, which was the next point visited. Here they are working three stamps of the Nordberg pattern with Wilfley tables.



QUINCY STAMP MILL, ON TORCH LAKE

The pumping plant for supplying water for both Tamarack and Osceola mills is of forty million gallons capacity per day of 24 hours. It is of the triple expansion type and was built by Nordberg Manufacturing Co. Capt. W. E. Parnall and W. E. Parnoll, Jr., had the party in "tow."

Again taking the train the next stop was made at the Quincy stamp mill No. 2, where Mr. S. B. Harris, Agent, and Mr. J. L. Harris, Assistant Superintendent, took the party in charge. This mill is equipped with three Allis heads 20"x24" and Wilfley tables, which have taken the place of the old style round tables in all modern mills, there being eight for each head. The boiler plant furnishing power for the mills consists of four vertical type Wickes boilers, being a duplicate of the No. 2 plant at the mine. The pumping plant was erected in 1900 by the E. P. Allis Co. and is of the yertical type triple expansion, the cylinders being 24" and 60"x42" stroke. It has a capacity of 16,000,000 gallons per 24 hours at a speed of 20 revolutions.

The last stop was made at the Tamarack-Osceola Copper Manufacturing Co.'s mill, where Mr. J. J. Case escorted the party through the works. Here were seen all sizes of copper wire from the largest to the smallest, in various stages of completion before ready for shipment, also copper plates and bars. The time now being limited but a hasty trip through the works could be made.

Much that was seen on this trip through the mills, smelter and factory was new to many of the visitors. From Dollar Bay the party took the train for Hancock and Houghton.

This concluded the excursion feature of the Institute meeting, delegates returning home on the afternoon trains, to winch they were escorted by their copper country friends, who were the recipients of many thanks for their hospitality.

CANDIDATES APPROVED BY THE COUNCIL AND ELECTED TO ACTIVE MEMBERSHIP.

Ahbe, F. R.,
Allen, W. J.,
Ames, A. F.,
Bayer, Henry L.,
Barber, S. S.,
Begole, F. H.,
Botsford, Charles W.,
Brackenbury, Cyril,
Brady, S. Howard,
Brandecker, Frank,
Brewster, Edward E.,
Brigham, E. D.,
Brown, Glenn Charles,
Browning, Richard C.,
Carmichael, Thomas,
Carter, R. B.,
Chinn, William P.,
Chamberlain, Morrow,
Chynoweth, James,
Clark, Alonzo Webster, Jr.,
Clarkson, James F.,
Clergue, Francis H.,
Coggin, Jr., F. G.,
Conover, Abram B.,
Cundy, Joseph J.,
Curry, George A.,
Dee, John B.,
Drake, Frank,
Drake, Marcus M., Jr.,
Dunn, Bird W.,
Dunstan, Thomas B.,
Fesing, Herman W.,
Flodine, Nels, P.,
Floeter, Albert Henry,
Formis, Andie,
Garberson, W. R.,
Lewis, Hartwell T.,
Linsley, W. H.,
Lord, A. W.,
Lord, Edward J.,
Lynch. Thomas F.,
McCarthy, M.,
McKeever, R. T.,
Manville, T. F.,
Marr, George A.,
Mars, Win. P.,
Michelson, Axel E.,
Monroe, W. G.,
Moore, Carlton Franklin,
Nichols, Frederick W.,
O'Neil, F. W.,
Osborn, Nathan Sanford,
Osgood, S. W., Jr.,
Parnall, William E., Jr.,
Penhallegon, Will. J.,
Peterson, Oluf G.,
Petersen, John O.,
Piper, James,
Platto, Frank,
Pryor, Reginald C.,
Pry or, John C.,
Raht, Charles,
Rees, Allen F.,
Richards, William J.,
Roberts, Enoch,
Roberts, O. T.,
Roberts, Harry,
Ryan, Edwin Patrick,
Sanders, M. S.,
Savicki, William Vaclay,
Searles, E. C.,
Seuter, Albert W.,

Gardner, W. A.,
Gay, Joseph E.,
Hardly, J. Wheeler,
Harper, George Vance,
Hartmann, Frederick,
Hayden, Jos. M.,
Hanse, George C,
Hulst, Harry T.,
Jackson, J. F.,
Johnson, Edward,
Jones, Charles Colcock,
Joyce, James Thomas Joseph,
Kent, Bamlet,
Keys, Frank,
Knox, John,
Krause, Charles H.,
Kruse, Henry J.,
Larson, E. T.,
Lathrop, J. H.,
Lawton, Nathan Oliver,
Lee, Matt,
Sherlock, Thomas,
Shields, James W.,
Shields, John C.,
Shields, Robert H.,
Smith, Willard Joseph,
Smith, Fred,
Smith, Philip Sidney,
Stevens, Horace J.,
Trebilcock, John,
Uren, Wm. J.,
Unzicker, Walter,
Vaughan, S. H.,
VanEvera, John R.,
VanOrden, Frank,
VanOrden, Mathew,
Walker, Elton W.,
Ward, E. T.,
Warren, Oscar P.,
Warriner, S. D.,
Wilcox, James,
Woodbridge, Dwight

FINANCIAL STATEMENT

Receipts.

Dues from Members	$ 799.93	
Sale of Proceedings	22.25	
Interest of deposits of treas.	16.85	
Total receipts	$ 839.03	$839.03
Balance from last report		310.99
		$1,150 02

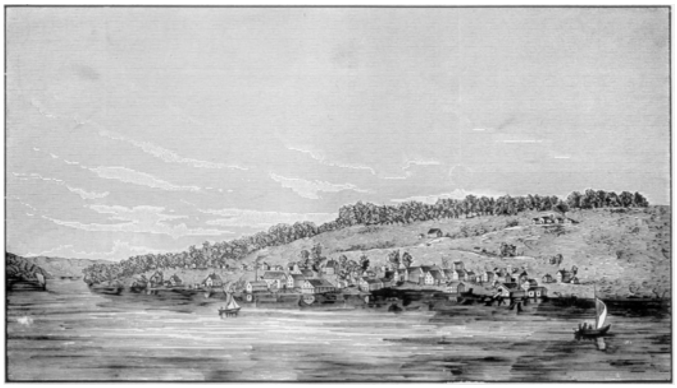
Expenditures.

Printing	$238.15	
Stationery	44.73	
Transportation	3.31	
Office Expenses	20.65	
Secretary's salary	100.00	
Total expenditures	$406.84	$406.84
Balance on hand		743.18
		$1,150.02

REGISTRY OF MEMBERS AND GUESTS IN ATTENDANCE AT THE 7th, ANNUAL MEETING.

Abeel, G. H.,
Ahbe, F. R.,
Allen, W. J.,
Ames, A. F.,
Bailey, F. M.,
Ball, Fdwin,
Barber, G. S.,
Barr, H. A.,
Beattie, S. T.,
Bjork, A.,
Blodgett, C. W.,
Bohman, O. E.,
Bohrer, A. D.,
Brady, S. H.,
Brewster, E. E.,
Brown, G. C.,
Browning, R. C.,
Linslev, Wm. B.,
Lord, Edward J.,
Longyear, J. M.,
Luxmore, John,
Lynch, T. F.,
Manville, T. F.,
Marr, Geo. A.,
Mars, W. P.,
McCarthy, M.,
McGee, M. B.,
McKee, W. E.,
McLean, J. H.,
McNair, F. W.,
McNeil, E. D.,
Michelson, A. E.,
Miller, Mixer, C. T.,
Monroe, W. G.,
Carbis, Frank,
Carmichael, Thos.,
Chamberlain, M.,
Chynoweth, James,
Clancy, James,
Clark, A. W.,
Clarkson, J. F.,
Cole, W. A.,
Collick, Alfred,
Collin, H. A.,
Conlin, Thos.,
Cooper, J. B.,
Copeland, F.,
Cundy, J. J.,
Curry, S. S.,
Deane, E. G.,
Dee, J. B.,
Dengler, Theo.,
Denton, F. W.,
Dickinson, E. S.,
Drake, Frank,
Drake, M. M., Jr.,
Duncan, John,
Dunn, B. W.,
Edwards, A. D.,
Elliott, Mark,
Elliott, S. B.,
Fesing, H. W.,
Fisher, H. D.,
Fisher, James,
Fitch, H.,
Fitch, W.,
Flewelling, A. L.,
Flodine, Nels,
Floeter, A. H.,
Formis, A.,
Garberson, W. R.,
Glanville. J. G.,
Goodell, H. S.,
Goodsell, B. W.,
Goudie, J. H.,
Greer, Howard, Jr.,
Hall, Josiah,
Harper, Geo. V.,
Hartmann, W. F.,
Harris, H. R.,
Harris. J. L.,
Harris. S. B.,
Hayden, J. M.,
Heath, Geo. L.,
Helmar, O. E.,
Herbert, O. A.,
Hood, O. P.,
Hopkins, E. W.,
Hosking, J. D.,
Howe, J. A.,
Howe, Geo. C.,
Hubbard, L. L.,
Hulst, H. T.,
Jackson, Geo. R.,
Jackson. J. F.,
Jeffs, W. B.,
Johnson, A.,
Johnson, M.,
Jones, O. O.,
Kent, B.,
Keese, F. E.,
Kelly, Wm.,
Moore, C. F.,
Morgan, D. T.,
Neal, A. C,
Neal, O. S.,
Newett, Geo. A.,
Olcott, W. J.,
Osborne, N. S.,
O'Neil, F. W.,
Parnall, W. E.,
Parnall, W. E., Jr.,
Peacock, Dan,
Pearce, L. O.,
Penhallegon, W. J.,
Perkins, Samuel,
Peterson, John,
Peterson, O. G.,
Phitzinger, G. W.,
Platto, Frank,
Poindexter, C. L.,
Powers, M. A.,
Prescott, F. M.,
Pope, Graham,
Redfern, John A.,
Reeder, E. O.,
Richards, W. J.,
Richardson, H. H.,
Roberts, O. T.,
Roberts, E.,
Roberts, H.,
Roberts, J.,
Roberts, R.,
Rough, James H.,
Rundle, A. J.,
Russell, James,
Ryan, E. P.,
Saricki, W. B.,
Scott, D. D.,
Seaman, A. E.,
Senter, A. W.,
Sheldon, Geo. R.,
Sherlock, Thos.,
Shields, J. O.,
Shields, Robt.,
Shields. J. W.,
Smith, Fred,
Smith, K. B.,
Smith, T. W.,
Smith, W. B.,
Smith, W. J.,
Sperr, F. W.,
Stanton, F. McM..
Stephens, James
Stevens, H. J.,
Sutherland, D. E.,
Swift, Geo. D.,
Taylor, E. O.,
Thompson, J. R.,
Thoney, James,
Trebilcock, John,
Trepanier, John,
Trestrail, W. O.,
Unzicker, Walter,
Van Evera, J. R.,
Van Orden, Frank,
Van Orden, Mathew,
Van Orden, W. O.,
Vaughn, S. H.,
Venney, F. A.,

Knox, John, Jr.,	Walker, E. W.,
Krause. G. H.,	Ward, E. T.,
Kukham, Geo. D.,	Warren, O. B.,
Koenig, Geo. A.,	Watrous, Paul, J.,
Lamb, E. E.,	Weber, Wm. L.,
Larson, E. T.,	Wessinger, H. J.,
Easier, F. G.,	Woodbridge, D. E.
Lathrop, J. H.,	Woodworth, Frank,
Lawton, O. A.,	Woodworth, G. L.,
Lawton, N. O.,	Young, R. C.,
Lee, M.,	Yungbluth A. J.,
Lerch, Fred,	
Lewis, H. T.,	



HOUGHTON, PORTAGE LAKE, IN 1859.

SOME EARLY MINING DAYS AT PORTAGE LAKE

BY GRAHAM POPE, PRESIDENT.

In the year 1845, the lands of the Portage Lake District of Lake Superior, having been surveyed, were made subject to purchase, and for three years, during the season of navigation, men of all sorts and conditions were to be found within its boundaries hopefully prospecting for copper-bearing fissure veins, returning to their homes on the approach of winter. These eager explorers, having soon found that an extraordinary amount of digging had been carried on from one end of the county to the other, and finding that the pits and trenches were comparatively modern, containing too, a vast number of stone hammers and occasional pieces of float copper with fragments of barrel work, were at a loss to know by whom the work was done, and why it was abandoned.

To us the explanation is simple enough if we dismiss from our minds the troublesome old theory of an ancient race coming from a far-distant southern land and spending only the season of navigation here.

When the Europeans made their appearance on this continent, they brought with them cooking utensils made of copper, hatchets, knives and axes made of steel, and all kinds of attractive ornaments for the person. The native Indian found it easy to obtain all these things in exchange for the skins of wild animals then so plentiful. He found them vastly superior to any he could make from copper which he could obtain only in the form of float, or of small pieces broken from the rough edges of masses. He therefore had no longer the need of hidden copper which was only obtainable by means of hard labor, always distasteful to him, and and so his mining operations were abandoned forever.

Two hundred and fifty years and more had passed after the red man had discontinued his work before the white man took it upon himself. There was then ample time for these pits and trenches to assume the appearance and condition in which they were found in 1845. There was no sign of any work done in the past other than that which could have been done by our modern Indian.

We have no record of any winter work in this district during the three years mentioned, except that a party of four men camped during the winter of 1846-7 near Whealkate mountain, and another party of perhaps fifteen men were engaged in actual mining in the neighborhood of Trap Rock river during the same winter, neither party knowing of the presence of the other. Three of the members of the larger party became famous in connection with this district, John R. Grout, Columbus C. Douglass, and John H. Forster. The latter gentleman has left on record an expression of his feelings of desolation during that dreary winter. It was no doubt emphasized because of his failure to find copper in paying quantity. For seven months this party lived without communication with the outside world. They drifted an adit under Douglass Houghton Falls, and opened the surface of the rocks in many places on Sections 19 and 20, Township 56, Range 32, without satisfactory results. Though considerable copper was found on these sections, the conditions were so disheartening that the enterprise was abandoned on the opening of navigation.

In 1847, Ransom Shelden established a store business at Portage Entry, and the steamers Napoleon and Independence occasionally anchored off the mouth of the river, there not being sufficient water to allow them to pass over the bar at the entrance. Before this season people bound for Portage Lake landed at Eagle River or Copper Harbor, thence coasted the shore of Lake Superior in Mackinaw boats until they reached the Portage some twenty miles west of Eagle River. A tramp of a mile and a half over the sand dunes brought them to Lily pond which emptied into Portage lake, eight, miles above the camps of the explorers.

Previous to this time there had been a large Indian village at Pilgrim river, and another at Portage Entry. These Indians, with the great number of coming and going explorers enabled Mr. Shelden to do a thriving business. A great deal of his time, however, was spent in studying the geological features of the district, and as fast as he acquired money and credit they were used to buy lands which afterwards became very valuable.

During these three years mentioned, the Mineral Range for twenty miles each way from Portage Lake was pretty well explored, so far as it could be done by individual effort, but as no copper had been found the approach of the winter of 1848-49 saw the district nearly deserted, and many of these people found their way to the gold fields of California. Those who remained worked on in hopes that the discovery of a rich deposit of copper would result in the organization of large capital, from which they would reap a rich reward.

A small party was at work on the hillside back of the present village of Hancock during the summers of 1847 and 1848, on Section 26, Township 55, Range 34, owned by James A. Hicks. In October, 1848, the Quincy Mining company having been chartered by special act of the legislature, and having bought Section 26, began, under the superintendence of C. C. Douglass, regular and systematic mining work by means of shafts and drifts, which was continued for many years without any satisfactory results. During this time indications of copper in quantity were sometimes found, filling the hearts of the people with hope, and in the year 1851 the prospects were so encouraging that Mr. Shelden moved his store business from Portage Entry to the Quincy mine. These prospects ceased to be encouraging, and the store was again moved in 1853, this time to Houghton where it found an abiding place.

In the autumn of 1851, Walter W. Palmer, beginning at a point about two miles west of where Houghton village is now, cut a road four miles long through the forest to Whealkate mountain, and on the S. E. ¼ of Section 17, Township 54, Range 34, established the Whealkate Mining company, the stockholders being New York people who were then interested in the Albion mine in what is now Keweenaw county. Mr. Palmer's first work was sinking a sand shaft which he was forced to abandon because of the abundance of water. He afterwards sunk a shaft in the rock and hoped by drifting to strike a fissure vein.

The provisions and supplies for this party were landed at Portage Entry, brought to Whealkate landing in Mackinaw boats, and thence packed through to the location. During the winter, Mr. Palmer having run short of some kinds of supplies, sent a man named McGee to the Quincy mine to get what was needed. McGee broke through the ice while crossing Portage lake and was drowned. This being the first death among the white people, the event caused much excitement and sorrow. In December, 1852, Mr. Palmer was succeeded by Capt. Joseph Pryor who continued the work until May, 1853, when it was permanently closed, after eighteen months hard labor during which no copper was found. In the absence of a banking system Capt. Pryor paid his men with orders on Capt. Edwards, who in turn, paid them with orders on John Senter then engaged in business in Eagle River. When a workman wanted money he could easily get it from Mr. Senter after walking twenty-five miles through the forest with his order. Mr. Senter never told these men to come some other day.

Capt. Pryor at one time gave the writer a statement of the work done at this mine by Mr. Palmer and himself. They sunk a vertical shaft in the rock to a depth of 40 feet, drifted south 20 feet, sunk at the head of the drift an incline shaft to a depth of 50 feet. From the bottom of this shaft they drove a crosscut west 100 feet, where they found a seam of laumonite. They drifted south on this seam 50 feet, and from the head of this they sunk a winze to a depth of 40 feet. Windlasses and buckets were used for hoisting and they must have filled and dumped the rock four times, wheeling it twice, a total of 170 feet, before it reached the surface dump.

From 1848 to 1852 with the exception of the men at the Quincy and Whealkate, the district was practically depopulated although there were always a few men digging here and there, hoping to happen on to a valuable deposit.

Owing to the exertions of Sheldon and Douglass, who by the way, were then and always afterwards partners in business, and who had come to have great confidence in the lodes of the district, having lost faith in the fissure veins, notwithstanding the theories of imported miners and geologists the attention of capitalists was attracted to this place in 1852, when the Isle Royale amygdaloid lode was discovered.

The Isle Royale Mining company acquired the N. ½ of Section 1, Township, 54, Range 34, for the purpose of mining this lode, and the work was vigorously prosecuted with great success in finding heavy copper. This mine was in charge of Mr. Douglass, who had become by this time one of the best posted men in the peninsula, having given much attention to the mining work at Keweenaw and Ontonagon which had by this time become important. He was at last successful in finding native copper in quantity in a lode or bed, and immediately began regular operations by sinking two shafts. When winter closed in he found himself short of miners, and he was obliged to go to Ontonagon and Eagle River on snowshoes to procure them.

In this year the Cacique Mining company was organized to explore the S. E. ¼ of Section 36, Township 55, Range 34.

In the spring of 1853 the fame of the Isle Royale lode was spread abroad, not only in the United States, but also in Europe, and a great boom was on. The Portage lode was found 200 feet west of the Isle Royale lode, and the Portage Mining company was organized to work both lodes at the S. W. ¼ of Section 36 Township 55, Range 34, under charge of Mr. Douglass. Three shafts were sunk and the hoisting was done with horse whims and whips. The lodes opened were well charged with copper. At the Isle Royale mine a two-flue boiler with a horizontal engine of 12-horse power was installed, being the first steam power used in the district. When the whistle was blown during the forenoon for the first time all the men quit work for the clay and indulged in a festal observance of the occasion.

At this mine a large dining room with a kitchen was built of logs, in which the men were never allowed, except for meals. Two log houses were built for sleeping and living rooms, one being occupied by the Americans and Englishmen, and the other by French-Canadians and Irishmen. Bunks in tiers were built around the walls, and each bunk was supplied with three heavy Mackinaw blankets. This became the practice at all the mines until many families came in.

During the year 1853, operations were begun by the Montezuma Mining company on the E. ½ of Section 35, Township 55, Range 34. Capt. Edwards was in charge of this mine, and opened an epidote-amygdaloid lode in which copper was found, but not in paying quantity. In May, 1853, the Albion Mining company, taking its name from the then idle mine at Gratiot River, was organized to mine the Portage lode on the S. E. ¼ of Section 36, Township 55, Range 34, which land was purchased from the Cacique Mining company, before referred to. Capt. Edwards was the agent and opened with an adit and three shafts one of which was rich in copper; carrying a good deal of nugget silver, because of which it was called the silver shaft. The hoisting was done at one shaft with a whip and at the others with horse whims.

Late in the same season the Sheldon Mining company was organized to mine the Portage lode, on Lots 3 and 4, Section 36, Township 55, Range 34, and was owned and worked by Sheldon and Douglass. Two shafts were sunk and an adit was driven under the sidehill. The hoisting was done with horse whims. In one of the shafts considerable copper was found.

In the autumn of 1853 the Huron Mining company was organized with Boston capital to work the Isle Royale lode on the E. ½ of Section 2, Township 54, Range 34. The lode was not found until February, 1854. Three shafts were then started and all showed rich ground. This was a cause of great rejoicing because it was the first large investment of Boston capital in copper mining here. From one shaft, 6x8 feet in size, there was taken out in the first 10 feet, three tons of mass and barrel work, and all the rock hoisted was very rich in stamp copper. J. B. Bennett was the agent of the mine, and he was also agent of the Ripley Mining company, which owned Lots 1, 2 and 3 of Section 31, and the S. ½ of S. W. ¼ of Section 30, Township 55, Range 33, on the north side of the lake, where it was supposed the Isle Royale and Portage lodes would be found, but nothing of value was discovered.

During the winter of 1853-54 the first dancing party was given in the double log house of Capt. Bennett at the Ripley mine. Some of the guests came from Ontonagon and Eagle River on snow shoes. While the dancing was going on those of the guests not so engaged stood outdoors in the snow where there was plenty room. There was great feasting and fun, and exchange of mining experience. A collection was taken up for the band. Each contributor seemed to think the others would not give much, for on counting it out of the hat they found $62. The band was one violin worked by the Webster mine blacksmith. They kept $5 for the cook, and gave him the rest of it.

The Dodge Mining company was organized in 1854 to mine the Isle Royale lode on the N. W. ¼ of Section 11, Township 54, Range 34. Two shafts were sunk on a hungry looking amygdaloid lode without mineral. They never found the Isle Royale or Portage lodes. They are probably 1,000 feet further west. From the Huron mine on the south to the Ripley mine on the north, everywhere on the line of these lodes were-found the Indian pits referred to, being particularly numerous on the Ripley location, where great quantities of stone hammers were stored, brought from the shores of the lake outside of Portage river. At the Portage mine on the Isle Royale lode a large pit was found where the Indians had worked down on the hanging side of the lode 10 feet below the surface of the rock. At the bottom of this pit was a floor of mass copper into which they could not penetrate. The pit marks showed that the work was done with the help of fire.

During the summer of 1853 the Pewabic Mining company was organized and bought the W. ½ of Section 25, Township 55, Range 34. Following the example of the Quincy company their work was confined for a long time to the sidehills and ravines facing the lake.

The success of the mines on the south side of the lake promised a permanent future for this industry and during the year 1853 a great many miners from Cornwall, Ireland and Germany came into the place, many of them bringing families. Because of this the village of Houghton was platted and lots were sold on easy terms to builders.

The whole of the present county of Houghton was organized into the one township of Portage, and on October 10, 1853, a special first election was held when C. C. Douglass was elected supervisor, the whole number of votes cast being 28. There being no opposition, but little interest was taken in the voting.

In April, 1854, the regular spring election was held, two tickets were put in the field and there was a most exciting contest for the officers. All mining work was stopped on election day, and so greatly had the population increased that 135 votes were cast, of which Richard Edwards received 63 and C. C. Douglass 72, the latter being elected supervisor. The voters from the north side of the lake spent the day in Houghton, and considerable friction was manifest among the different nation-nalities, growing out of the fact that a great many men were prevented from voting by the challengers who required proof of citizenship. This was sometimes referred to as the "Nose Bleed" election.

In the spring of 1854 the Huron Mining company, decided to use steam power at one shaft and a purchase was made of a locomotive boiler with engine and drum attached. Capt. Bennett made up his mind that that plant should go up the hill by means of its own power. So with an equipment of rollers, blocks and tackle, with steam up and a lad of fourteen years, C. D. Sheldon at the throttle, a start was made with Capt. Bennett in charge of the blocks. The people assembled in great numbers to see the work, and voted it better than a circus. During one performance Bennett rushed down the hill at great speed using language carrying a high percentage of profanity. When Sheldon got block and block he found a number of Bennett's fingers on the ground, and then he knew what was the matter with Bennett. They got the plant up to the mine, a mile and a half, in ten clays.

In the spring of 1854 the Isle Royale company began building a stamp mill, and in October the mill was pounding rock. In November, 1854, this company made the first shipment of Portage Lake copper. It was loaded on a scow which was poled along the shore and reached Portage Entry after a toilsome voyage of 24 hours. The copper was there transferred to the steamer Napoleon for shipment to Pittsburg for smelting.

The rock for this mill was roasted in kilns and when the wood was all burned water was thrown on to crack the rock which was then broken small enough for the stamps with hand hammers, then hauled to the mill in wagons. The stamping machinery consisted of 16 heads of Cornish stamps with a large cast iron axle into which were driven wooden cams. The number of stamps was soon increased to 24 heads, and the capacity of the mill raised to a maximum of 36 tons in 24 hours. Owing to breakdowns so much time was lost that the best month's record in its history was 800 tons in 26 days. T. A. Trevathan who worked in the first stope in the mine was put in charge of the mill.

During the year 1854 the Albion Mining company built a stamp mill with 16 heads before they had much ground opened. The result was the stopping of the mine, the failure of the company and the forced sale of the mill machinery.

The boilers for this mill were hauled around the rapids at the "Soo" and loaded on a steamer for Portage Entry. No lighters were to be had and the boilers made two or three voyages. Finally under the charge of J. B. Lyon, late a member of this institute, all the openings being plugged, the boilers were launched overboard. One of them came back at the steamer and knocked a big hole in her side, but fortunately, above the water line. The boilers were well roped together, the dooms being kept upright by means of heavy planks bolted across them. A large sail was hoisted and the boiler catamaran sailed into the river. A large Mackinaw sail boat was then chartered to go ahead with a long cable and the whole outfit sailed up Portage river and Portage lake 15 miles to Houghton, where the boilers were pulled ashore by cattle power.

The engine in the Albion mill was thought to be near perfection. It was a beam engine 32 inches diameter of cylinder with 72 inches stroke. It was used for 20 years afterwards by the Isle Royale company, when it was destroyed by fire.

In 1855 the Portage Mining company built a stamp mill in Houghton village, hauling the rock to the mill in wagons after it had been prepared as above mentioned. The mill had 16 heads of Cornish stamps and a capacity of 24 tons per day when in good order.

In both the Portage and Isle Royale mills only selected rock was stamped and the cost of stamping was from $2.50 to $3.00 per ton. A great deal of copper was lost owing to the crude form of washing then in vogue.

Daring the season of 1854a great many people came into the country but there was not work for all of them. At this time the Albion mine was closed and its discharged employes increased the force of idle men. In January 1855 orders came to all the companies to reduce expenses and a panic was on. The boarding house people could not afford to board idle men until spring without payment, and so some 400 men started through the forest for Green Bay which was at that time the nearest large settlement. The weather was very cold, the snow was very deep, and the travelers were without snowshoes. The sufferings of these men were terrible. With frozen hands and feet and faces, they made their weary way with insufficient food. Five persons were known to have died on the way and some were never heard of again.

In the spring a more hopeful feeling prevailed. An assessment was called by the Isle Royale company, and W. E. Dickenson became agent. A tramroad was built from the mine to the mill, one and three-quarters miles long including sidings. The loaded cars, holding two tons each, were hauled to the head of the incline by horses. This incline was so flat that a yoke of cattle was used to start the descending train, after which it managed to run to the mill taking up the empty cars. The train would, however, often perversely stop half way down when the cattle were sent after it to give it a fresh start. It was said that the new method was cheaper than the old one of wagon haulage.

During the year the work at the Quincy and Pewabic was pushed forward with shafts, adits and pits without success. Explorations on the shore lands west of Houghton by Pittsburg and Boston people were continued until winter, and a number of prospectors were at work on the Highlands south of Houghton.

In 1856 after three years effort at the Pewabic location and eight years continuous effort at the Quincy location, the great, Pewabic amygdaloid lode was uncovered by the Pewabic company, when both companies had become almost disheartened and with the treasuries empty. The lode was immediately located by the Quincy company and from that time forward the work never halted. Samuel W. Hill was put in charge of the Quincy mine and Charles H. Palmer of the Pewabic mine.

During the season of 1856 a great many Irishmen came in and found plenty of work at these new mines. In the autumn of this year there was a great row at the Minnesota mine where a number of Cornishmen and Irishmen were injured and one Cornishman killed with an axe. On receipt of the news at Portage Lake all the mines stopped work, and some 400 Irishmen gathered on the Quincy dock prepared to march to Ontonagon through the forest for the mad purpose of killing every Cornishman. After many hours of hot discussion wiser counsels prevailed and the proposed massacre was abandoned. Messages had been sent to Ontonagon warning the people of the threatened invasion, and the steamer Illinois left that port well loaded with passengers seeking a less strenuous people.

Soon after this the general election was held when out of a total of 180 votes in the present limits of Houghton county John C. Fremont electors received 36, and James Buchanan electors 144.

In 1857 the Franklin Mining company was organized to work the Pewabic lode on the S. W. ¼ of Section 24, Township 55, Range 34, under the same management as the Pewabic company.

The success of these companies was so great that each decided to build a stamp mill. The Pewabic company built their mill in 1858, and the Franklin company in 1859. These two companies were the first to use the Ball stamp in this place. The stamp shaft was 6 inches in diameter, the cylinder was 9 inches with 24 inch stroke. The capacity was from 80 to 100 tons per head per day. The cost of stamping was from $2.00 to $2.25 per ton.

When Mr. Ball was asked why he used spring timbers under the heads, he said, “I am building these stamps.” Being of an impetuous temper that was not all he said. The number of heads was soon increased to 4 in each mill, and gave great satisfaction.

The Quincy mill was begun in 1859 and completed in the spring of 1860. It was a Gates drop stamp, but so improved over the Cornish stamps in use in Houghton that each head crushed three tons per day thus giving the mill with 60 heads a capacity of 180 tons per 24 hours.

The mill was always slopped four weeks every winter for general repairs.

The washing machinery at the Quincy was an improvement of that in use at the Houghton mills, but at the Pewabic and Franklin mills, Mr. Ball introduced his rotary washers, which were a great improvement over any other methods, in the way of saving labor, but were exceedingly wasteful of the copper, which was a matter of great satisfaction to the men who had the tailings on tribute.

In 1859 the Quincy sold to the Hancock Mining company part of the S. W. ¼ of Section 26, Township 55, Range 34, reserving, however, the right to mine thereon the Pewabic lode. The Hancock company opened a lode to the west which gave them considerable copper. In this same year the Columbian Mining company fought the Albion mine which had stopped in 1854 as above stated and began again the development of the Portage lode.

The great success of the Pewabic lode, which continued to be rich in copper in all the openings, attracted still further the attention of Boston capitalists, and a number of mining companies were organized to work that lode to the north, namely the Mesnard, Dorchester, St. Mary and Albany and Boston. The two latter companies do not seem to have found the lode, but spent much money on an amygdaloid-epidote lode which proved worthless.

Both these companies opened the Albany and Boston conglomerate, now known as the Allouez conglomerate, which often looked well in the drifts and stopes, but under the test of stamping failed to be profitable because of the necessity of breaking out many tons to get one ton for the mill.

The wages paid previous to 1860 were about as follows: Mining captain, $75.00; second captain, $60.00; timbermen, $50.00; helpers, $35.00 to $40.00; landers, $31.00; wheelers and fillers, $29.00; teamsters, wood choppers and surface men, $28.00 to $29.00. blacksmiths, $35,00 to $50.00; engineers, $32.00; carpenters, $31.00 to $40.00; boss carpenter, $51.00; company account miners, $37.00; contract miners, $45.00 to $50.00. Board was $11.00 to $12.00 per month.

The success of the mines on the Pewabic lode being assured, the Quincy company laid out the village of Hancock which immediately took rank with others of the peninsula. The broad and high plateau of sand and gravel had great natural advantages over the rocky hill side on which Houghton was built.

During the time of this growth of the copper industry, all merchandise and machinery was brought to Portage Entry by steam or sail vessels, where it was transferred to lighters and towed to the docks of the mines and villages at a cost of $4.00 per ton. In 1859 the producing mining companies with Sheldon and Douglass, organized the Portage River Improvement company and dredged out the bar and other shoal places so that in November, 1860, the steamer Illinois drawing 10½ feet of water came to Houghton with 400 tons of freight onboard. The work was continued the following year so that any boat able to pass the “Soo” locks could enter Portage lake. Previous to the opening of the river, all passengers, mail, express and baggage were transported from Portage Entry by light draft tugs and steamers. There were, as is usually the case, two rival lines, but which never reduced the rates.

A ferry was early established by an old salt water sailor named Sam Eales, who took passengers across in a yawl boat when he felt inclined to go. In 1857 or 1858 John Martin bought out the good will of Capt. Sam and replaced the yawl with a swift moving little tug. The contract with Eales, required Martin to furnish him board, lodging and clothing so long as he should live. Martin thought from Eales mode of life that the contract would soon terminate, and often abused the old man for being so healthy. Capt. Sam, however, lived some twenty years or more in blissful ease and comfort at Martin’s cost.

The arrival of the first boat in the spring was an event which will never be forgotten by those who lived here in early days. A lookout was kept on the Pewabic bluff and when the boat passed the Huron islands notice was given and the whole population, men and women, made for the water side. As soon as the steamer reached the dock it was taken possession of, and no freight could be landed so long as the trader had any remaining eggs, fruit, vegetables, or any articles which the people had been deprived of so many winter months. The demand for newspapers was extraordinary because for a month before navigation opened no overland mail could be brought through. The steamboats of those days made the voyage in much less time than is done now, when passengers travel only for pleasure.

At that time there was no railroad nearer than Green Bay, and all mail and express matter, as well as passengers came by boat. The tables were always well supplied, and the officers never wearied in making the people comfortable. Every boat had a saloon. In the day time there was much card playing and in the evening always music and dancing. In the winter the mail was brought in by dog trains and was always uncertain. Your expected letter might come or it might be in one of the bags hung in a tree, or in one used to help out the carrier's camp fire.

All the copper produced was sent to Pittsburg or Cleveland for smelting until the close of 1860, when the local smelter was established.

The product of Lake Superior for 1860 was about 5,000 tons, and the president of one company objected to calling an assessment because he feared the over-production would make the business unprofitable before he could get his mine in shape.

Up to this time and for many years afterwards, all underground work was done with hammer and drill and black powder, pick and shovel and wheelbarrow. The hoisting was done with kibbles and buckets, with hemp rope or with chains. No mining engineer was required and the manager who could not work out any problem was not fit for his job. No company had any money in its treasury, and while supplies for mining work were always scarce, none at all were to be had during the long winter. All sorts of expedients were resorted to to get things going again when breakdowns occurred, and it is a wonder that so much was done, and done so well.

Before the years which are included in this paper, there were no technical schools in America, except the institute in Troy, New York, which in those days taught nothing in mining engineering. Nevertheless, there were many men of liberal education, of fine culture, and of great natural ability, who sought the opportunity to take up their life work in this place. As is always the case in any pioneer district; so it was here, that men of enterprising minds, of unwearied zeal, of unflinching courage, were among the first to penetrate the wilderness. They were full of resource and accomplished great things. They were full of human kindness and never failed their neighbors in distress. They were hospitable and the stranger was ever welcome if he was a manly man. This generation is to them greatly indebted.

This little story closes with the year 1860, but it may be well for the writer to refer to a few things of later happenings which led to the great changes in mining methods in the copper region, and which otherwise may never be told.

In 1864 John Mabbs became the agent of the Isle Royale mine. He was without previous experience in mining, being a machinist by trade. His mine was poor, there was no money in the treasury, and the frequent assessments took care only of the floating debt, and yet his record stands out as a singular one in the introduction of saving methods. He introduced the large drum for deep hoisting by installing one of 16 feet diameter at No. 5 shaft. He also put in a flat band hoist at No 8 shaft, with a 16 foot sheave thus increasing the speed of the rising skip. This flat band idea was taken from the band Mr. Dickenson used on the gravity tramway before referred to. It was made of sections of flat steel 4 inches wide, ¼ inch thick and 30 feet long, which were butted together, and over this joint a piece of the same steel, six feet long was carefully riveted. Whenever a break occurred the blacksmith riveted another plate on so that it was very lasting. The depth of this shaft was 800 feet. Mr. Rand having introduced a heavy drill for tunnelling, was persuaded by Mr. Mabbs to make a light and portable one for mine use. He then made a compressor out of some old engines at the mine. Having also a lot of cast iron pipes of different sizes, he made them tight together by driving in wooden wedges at the joints, and thus successfully introduced the power drill with compressed air sending it 2,000 feet. He found in Chicago an incomplete and unworkable diamond drill which he bought and took to M. C. Bullock who perfected it. It was used here for some time and afterwards sold to the Quincy company, and it is well known what it did for them.

The story of the introduction of high explosives is so interesting that I venture to give it at length. In 1870, I think it was, but possibly in 1869, Mr. Mabbs bought in New York 4,000 pounds of the pure nitro-glycerine oil which was contained in 100 tin cans. The oil was thirteen times stronger than the black powder then in use. About this time a number of terrible accidents occurred from the use of this oil, and a great outcry rose against it, but after much trouble he persuaded one of the Pennsylvania coal carrying roads to take it. Unfortunately news of its shipment was sent forward when a mob assembled and stopped its passage. It was then sent back 100 miles, transferred to another road and finally reached Cleveland. Mr. Mabbs, fearing arrest for violating the city ordinances, was anxious enough to get away, but could get no steamboat to take it, and as few sailing vessels were bound for Portage lake it was only after great trouble he was able to persuade a master to take it to a powder magazine above Hancock. The Hancock authorities having heard of its presence promptly ordered it out of the place and it was removed at night to an old stope in the mine. A few days after this orders came from the east to close the mine, and he had time only for a few blasts. Nothing disheartened he persuaded the Huron mine agent to allow its use there with the understanding that he was to do the blasting. He put up a little magazine back of the burrows and under cover of darkness put there one can only of oil, containing 40 pounds. The miners became so excited and furious that they stopped the mine. A great mob gathered and preparations were made to ride the enterprising agent out of the place on a rail, but they did not get him. That night the mob blew up the magazine thinking all the stock was there. It having leaked out that there was more of it, searching parties were formed to get it. It was moved half a dozen times just in time to save it, and finally it was hidden in the woods just east of where the Mining school now stands. Mr. Mabbs and his brother had in each case handled the oil themselves. They finally loaded it into a yawl boat, and started with it for Marquette, which place they reached in safety after a narrow escape from being lost in a storm on the lake. They got permission to try it on some of the hard heads in the iron mines, and were so successful they had no trouble in closing out their stock and the use of this material was continued there to a limited extent until the present method of making it was adopted, when its use became immediately general.

DISCUSSION.

MR. COOPER: On account of the paper which I will read, I shall certainly question your statement as to the copper being shipped to Pittsburg until 1860. The Detroit works were opened in the fall of 1850, and I think copper was shipped there.

MR. POPE: That is correct as to opening of Detroit works. but was there any Portage Lake copper shipped to Detroit?

MR. COOPER: I think to the Detroit works, yes, sir.

MR. POPE: The copper that was smelted there was copper from Ontonagon County and Keweenaw County, or possibly the small quantity of Portage Lake copper found by explorers.

MR. COOPER: I may be wrong in thinking that it went to Detroit, but I believe not. I am not positive and cannot state absolutely that that was the fact, but I think some of the copper went to the Cleveland works (to Hussey & Company) the same people who were interested in the Pittsburg Works.

MR. POPE: That will leave the question open still, but I will make my paper to read Pittsburg or elsewhere.

STEEL CONSTRUCTION FOR MINES.

BY J. F. JACKSON.

It is quite in line with the doctrine of contraries that a resident of a section of the upper peninsula, where copper is the chief product, should be called upon to talk to an audience composed largely of iron country poeple on the general subject of steel construction for mines.

It is a fact that the copper mines of this district and of the west have gone into steel construction more extensively than have the mines whose product is the ore from which steel is manufactured. There are, of course, many reasons why this should be so, chief among which, is perhaps the fact that the shafts, machinery and equipment, about the iron mines are not generally of such an extensive or permanent character, nor do they have to meet such exacting requirements as the various mining plants in copper production.

Our iron country friends are, however, gradually beginning to appreciate the usefulness of their own product. On the other hand, the iron counties have been much in advance of ourselves in the matter of electric street railways, electric mine hoists and pumps, and electric underground tramming, in which construction copper enters so largely.

These examples are only new illustrations of the old saying about the shoemaker's wife having no shoes. The nineteenth century has been called the Iron Age. It should be called the Age of Steel and Sir Henry Bessemer*s epoch-making invention has been ranked next in importance to that of the steam engine itself. These two great inventions have been the foundation of the iron mining industry. Whether the new century, whose coming greatness defies the imagination, shall be distinctively the age of electricity, greatly increasing the use of copper, remains to be seen. Possibly there may be developed in the near future some 16 to 1 ratio between the black and red metals, which shall form a sound basis for continued prosperity in the upper peninsula, because we have both precious metals, and in great abundance.

There being but two practical forms of building for most mining purposes, the present paper will be largely devoted to comparing the merits and advantages of wood and steel. This task is undertaken with the idea of making comparisons as fair as may possibly be made by a man in my particular business.

As the representative of a prominent manufacturing company it has been my function to assist somewhat in adapting steel construction to the various classes of buildings and other structures erected for iron and copper mining, and auxiliary uses. It is the purpose of this paper to point out some of the advantages and disadvantages of so-called steel buildings. In the large cities and manufacturing districts, experience has developed for shops a type of construction in almost universal use, viz: a steel frame structure to carry all roofs, machinery, and loads from traveling cranes; which frame work is encased by light brick or terracotta walls, or occasionally a covering of corrugated iron. The steel skeleton sky scrapers of the great cities are generally of analogous construction. That is, all exterior and interior walls, floors, etc., are carried on the steel frame work. Such buildings, although with wooden floors, doors and window frames, and containing furniture and combustible merchandise, are generally called fire proof buildings—at any rate the fire risk is reduced as far as is commercially practicable.

NO. 5 TAMARACK STEEL ROCK AND SHAFT HOUSE.

In the Quincy machine shop and Quincy pump house at the stamp mills, we have two fine examples of steel frame and brick construction. This type of construction is, however, obviously not well adapted to shaft and rock houses and stamp mills where there is a great deal of straining and jarring. In this region of severe winter weather we must necessarily make some extra provision to keep out the cold. To accomplish that purpose we have sometimes used considerable wood sheathing in addition to the corrugated iron covering. This is a great disadvantage and you have made a valid criticism when you state that many steel buildings contain entirely too much wood. I am, however, prepared to show that in most steel frame buildings, where wood is used for sheathing of sides and roof, it is used in such away that there can be but little chance for fire to spread.

There is, however, one disadvantage in steel structures, which has been dwelt upon by some theoretical and so-called practical people, and that is the fact that they are not so readily overhauled, patched up or strengthened as are wooden buildings when they prove to be poorly designed or too weak for the purpose for which they were built. It is argued very gravely that buildings of timber can much more easily be repaired, columns and beams strengthened and bracing put in when found necessary. My reply to this h that this may be a strong point against the steel building if designed entirely by guess, but it is well to bear in mind that the days when bridges of wood and steel were built by guess have long gone by; guess work has been superseded by mathematical analysis, and the days of the man who designs large structures of any sort by guess with the comforting thought that he can find the weak places and strengthen them afterwards, when necessary, are also numbered, and he must give way to the man who can design a machine, a tool or a building to meet certain specific requirements in a practical and economical way with reasonable assurance that the thing will work successfully when completed.

Coming now to the advantages of the steel bridge, gallows frame, stamp mill, shaft house, etc., we believe that there has been developed a style of construction which contains a minimum amount of wood; is practically safe against ordinary fire risks and meets all climate requirements. I do not call this type of structure a fire proof building, because such a thing has literally never been built, but have generally referred to it as a steel frame building; even steel and brick are not strictly fire proof. The advantages of this practical building may be classified as follows: Decreased fire risk; durability; rigidity; decreased cost of maintenance; adaptability; better light and moderate cost.

On the subject of decreased fire risks in the type of construction now in use for stamp mills, I think an unprejudiced and capable observer would agree that, taking into account the character of the contents in both cases, we have practically as little danger from fire as the merchant or warehouse man with his expensive fire proof structure. In designing structures for particular purposes, this matter of fire resistance should, of course, be given careful consideration and sound judgment will generally determine the happy medium of low cost and practical safety from fire. In the four boiler houses constructed for the Isle Royale Consolidated Mining company during the last two years, may be seen a happy combination of stone and steel structure, very reasonable in first cost, and worthy of imitation. These buildings are about 45x70 feet in plan. Each end and a portion of each side of the building up to the level of the eaves is built of common rubble. The roof trusses, gable ends and a large portion of each side are of steel frame construction. Pump houses and compressor houses are now generally made with stone walls or with steel frames, so arranged that corrugated iron and wood sheathing may be replaced at some future time with brick walls, should the price of brick get down to a reasonable figure. A pump or compressor that costs from $20,000 to $30,000 should be entitled to the protection of a first class building.

This is probably the right place to call attention to the overwhelming importance of having an equipment of machinery, buildings, etc., of such a reliable character that the mine may be kept in operation night and day the year around. A very considerable increase in first cost is warranted by this consideration alone, because running expenses go on just the same. The eastern director or stockholder thinks of decreased earnings and has bad dreams as soon as a fire or serious breakdown occurs at the mine. It is no longer possible to go to the woods and get out timber to replace a burned rock house or stamp mill in a few weeks. This scarcity and increasing cost of wood as well as the loss of production, loss of property and lives, which have occurred in the past, are valid arguments which make the construction of a wooden rock house no longer defensible. The business of producing copper from an established and successful mine is of such a regular and permanent character that good business policy demands the installation of the best machinery and the best buildings.

Andrew Carnegie's great wealth and his supremacy in the iron and steel business were largely due to the fact that only the best was ever good enough for him. He has been called the greatest 'scrapper' on earth. As an instance we may mention that the immense 150-ton steam hammer costing $250,000, a model of which was shown at the World's fair, was thrown into the scrap heap after three years' service, because hydraulic presses were found to be more successful for heavy forging than steam hammers. As a successful manager of large industrial enterprises Carnegie stands without a peer. He has taught the lesson that we must all keep abreast of twentieth century progress if we would be successful in a large way—in our case always presuming, of course, that there is iron ore or copper in the ground willing and anxious to be taken out and sold at good figures.

Under the head of durability of steel for mining structures, I think it may be fairly said that the conditions are no more trying about a mine than in railroad and highway bridges and manufacturing buildings. To be sure there are destructive gases arising from upcast shafts, but their effect on steel work is no worse than the effect of locomotive gases on trusses of train sheds and overhead crossings. Their corroding effect may be provided against by covering, painting or by protective sheathing of asbestos papers or other effective means. Many of the earliest metal bridges are still in use after a half century of service and no particular care. Where they have had to be replaced it has been more often on account of the necessity of providing for heavier loads than for any other reason. I think it is without doubt a fair contention that a well designed steel building will outlast and require a much less annual expenditure for maintenance than a building of wood. Any unprejudiced observer can hardly fail to be convinced on investigation that the high grade and permanent character of the equipment of the Isle Royale mine, lying just south of Houghton, will mean a greater economy in the operation and maintenance of its plant than has elsewhere been effected in the copper country. The usually very large item of surface work should in this case be reduced to a minimum.

Right in line with this statement comes the observation that with the introduction of steel buildings and high grade machinery has come a larger appreciation of the value and importance of labor saving appliances, in which matter we must confess that mining people are generally much behind their brethren in the manufacturing field. In this matter Carnegie has also been foremost. The development of labor saving machinery in the manufacture of steel and, indeed, in all American manufacturing enterprises, is the wonder of the world, and has enabled the United States to compete successfully in every manufacturing center of Europe, while paying larger wages to workmen than are paid by their foreign competitors. With the introduction of the steel buildings has come the possibility of overhead traveling cranes, trolleys, air hoists, and various other contrivances. A larger appreciation of the possibilities in the way of labor saving and fuel saving machinery and devices is a hopeful sign of the times.

It used to cost 20 to 30 cents per pound to make copper. By the introduction of power drills, high explosives, ball stamps, first motion hoists, etc., and the carrying on of operations on a large scale the cost has been brought down from 7 to 10 cents per pound. Does any one deny that there are still greater economies to be obtained?

It will continue to be my purpose to advocate in season and out of season more careful consideration of problems in labor saving, especially. A natural personal aversion to muscular labor may be at the bottom of this contention. My English father used to intimate as much when I was a boy on the farm. True, it always makes me feel sad to see good human muscle in the shape of main strength and awkwardness doing work which could be done much more economically by steam or by electricity. There are more lazy boys now than formerly. Let us no longer emulate the hard-working mule. When I proposed an easier way of accomplishing a piece of work, I was called lazy, and was comforted by the reflection that a lazy boy in Stephenson's time made the steam engine work automatically, because he was too lazy to turn the valves; he was an early apostle of the new industrial gospel of labor saving.

Another advantage of the steel building, especially for stamp mill work, is the possibility of obtaining a much better lighted structure than with the old style building. Columns may be placed at any convenient point, roofs may be made high with beams or truss spans of any convenient length. It is no longer necessary to fill the air with a net-work of heavy wooden posts, beams, girders, etc., to shut out the light of day. Good light and good paint are conducive to cleanliness and good order. Workmen are in better spirits, do better work, and keep their machinery in better order where their surroundings are cheerful and attractive. Let us have well lighted buildings.

Probably the most important advantage of the steel building for mining purposes is the possibility of making it rigid. Many wooden rock houses especially are afflicted with nervous vibrations from the jerking of ropes on head sheaves and from the unbalanced reciprocating parts of steam engine and rock crushers. Wood has the natural quality of absorbing shocks and vibrations to a greater extent for a given strength of beam or column than steel. This natural quality is, however, much more than offset by the practical impossibility of obtaining rigid and effective connections between the component parts of a building. In the old mortise and tenon system of framing timbers, now happily a relic of the past, it was possible to obtain in the connection of a beam to a column perhaps one-quarter to one-third of the full strength of the timber. Under that system knee braces could only be connected at each end by tenon and small pin, so that they were practically of no effect except to take compression. Splices in long columns or beams were both clumsy and inefficient. Of late years some progressive builders have taken to using cast iron angle brackets and iron bolts for connecting the heavy timbers in a building. With good timber fairly good work can be done in this manner and there is a possibility of tightening up loose joints as the timber shrinks or joints work loose. But good timber suitable for heavy framing is now getting to be a scarce and expensive article; besides, as intimated earlier in this paper, too little figuring has been done and too much dependence has been placed on the mass of timber put into a structure. The thorough bracing of a modern rock house to take up strains from vibrating machinery or from head sheaves has seldom or never been accomplished in wood. To brace such a structure in as thorough and effective a manner as is done in the modern steel rock house will usually cost practically as much money as it does in the steel building.

In contrast with the inefficiency of ordinary wood bracing we have in steel construction a very great advantage in the line of efficient bracing. In the first place the connections and ends of girders and beams and the splices in columns, if required, can be readily made to develop the entire strength of the girder, beam or column. The rigid riveted connections add tremendously to the stiffness of the structure. Again the stiff bracing generally employed to transmit vibrating of static strains is capable of acting in either tension or compression and there are no loose joints to work still looser from the continual shaking, which the building has to undergo. The success or failure of a steel structure carrying moving machinery is largely due to the skill or lack of it which the designer displays in providing efficient and direct systems of bracing to take up the vibrations set up by reciprocating or unbalanced parts. There is something more than the mere static loads to be provided for and experience has taught that high factors of safety must be used as well as stiff bracing and rigid connections. We have found that there is no particular difficulty in putting machines, shafts, large mill engines or rock house engines up in a building 30 or 40 feet from the ground if these principles are borne in mind. This often enables us to dispense with the services of a special engineer to look after the engine. Besides, there may be many indirect savings in belting and shafting and other advantages to be obtained by locating the engine well up inside of the building and close to the work. In general, I think we may assume that the steel building for mining purposes will soon come into universal use, and be found as readily adaptable to special requirements as has been found the case in manufacturing plants. The advantages in the line of lessened fire risk, durability, maintenance, light, stiffness and adaptability are so plain that no observing or progressive mining man can afford to be behind the times in this matter of steel construction.

In the iron country, particularly on the Gogebic and Mesaba ranges, quite a start has been made in the way of building steel gallows or head frames. More of them are sure to follow.

While in many cases the first cost of the steel building will slightly exceed the cost of a similar structure in wood, it is maintained by parties who have put in equipment in both cases that there is little difference in the total final cost. Any excess of first cost is offset many times by the other advantages which we have enumerated.

In the last two or three years many more or less new uses of steel have been found. In the copper country many large self-supporting brick-lined smoke stacks hare been built. Steel frame slime tables with concrete tops have been introduced and found to work successfully. Large steel cylinder drop shafts have been sunk through 75 feet of sand to solid rock and filled with concrete to form a solid foundation for stamp heads. A large underground pump chamber is being lined with sets of I beams, lagged with corrugated iron arches and concrete. Extensive steel coal handling machinery has been put in. Perhaps the most notable of all new departures is the new steel and concrete dam now under construction for the Atlantic and Baltic mining companies at Redridge. This is about the second or third and by far the largest steel dam ever constructed. It is absolutely novel, in that it has a concrete base with inverted V shaped superstructure of steel bents covered with boiler plates so designed that it acts as a gravity structure to resist overturning movements due to hydrostatic pressure. Besides having all the elements of stability necessary in a well designed masonry dam, it has many elements of safety not possible in the masonry dam, chief among which is the fact that the entire steel structure 472 feet long and from 30 to 74 feet high, may be conceived to act as one long girder from end to end. A masonry darn consists of many thousands of separate pieces, more or less perfectly cemented together with mortar. On the contrary the steel dam will be riveted together so as to form practically one huge million-pound mass of steel anchored into a concrete base, making it one unified and inseparable structure. Many of you have had an opportunity to visit the site today. A detailed description of this dam will appear in the technical journals some time next summer.

It would be a pity to pass by such a glorious opportunity for giving advice as is afforded at this time and place. I will cut it short. Experience is a good guide but a slow master. The great achievements of the nineteenth century will be eclipsed by those of the twentieth century. Let us not continue to make martyrs of every man with a new idea. Iron and copper, the king and queen of the new industrial world, are monarchs of progress and enlightenment.

MR. JACKSON'S PAPER OPEN FOR DISCUSSION.

MR. KELLY: The explanation of the fact that the iron districts are behind the copper country in the permanence of buildings may properly be amplified. The chief reason given for this in the exceedingly interesting paper we have listened to is that "the shafts, machinery and equipment about the iron mines are not generally of such extensive or permanent character" as in the copper region. But the first cause is both figuratively and literally deeper seated and is to be found in the character of the ore deposits themselves. Where the measures are highly tilted it is usually impracticable to prove the deposits far in advance of mine openings, and the majority of the iron ore deposits are so irregular in shape and direction, to say nothing of their purity and commercial value, that a continuance of operations tributary to a shaft is far from being assured. In many cases it may be even said that exploitation is largely experimental. An interesting paper might be made on the life of shafts in the iron country; and I have thought that if the history of operating shafts was collated it may be found that the average life is less than ten years. However that may be, the character of the surface equipment and structures is necessarily largely dependent on the expected life of the underground operations about each shaft.

MR. OLCOTT: I would like to know if a steel shaft house was not erected on Gogebic Range before such structure was completed in the copper country?

MR. JACKSON: I think in my paper I stated that one of the chief reasons why the iron country had never used steel structures was the fact that their equipment was of a less expensive character. I am not posted on the matter of the question and cannot answer on that point.

MR. POPE: The construction of the steel shaft house in this country is a new proposition to us. Mr. Denton may know something of the date referred to. Of course the Calumet shaft house was not in commission until after the Aurora shaft house. I don't know whether it was begun before or not. It was a long time under construction.

MR. JACKSON: Mr. Olcott has the date of that Aurora mine structure. Do you remember it?

MR. OLCOTT: The contract was let in September, 1897.

MR. OLCOTT: There is one thing Mr. Jackson has not spoken of, and that is the use of steel for timbering shafts. Have you given any thought to the question of timbering the shafts with steel?

MR. JACKSON: I am not aware that that has been done here. It has been done in the coal countries and has been proposed in various places, but I do not think that this is the proper thing to do here in the iron country or copper country. I may be wrong. I think the shafts are timbered here. I know I figured various schemes for doing away with stull timbers and couldn't strike anything to be as economical as timber. I do not think the time has come when steel will be used for framing shafts here. It is used in the coal countries.

MR. OLCOTT: I suggest that the Oliver Mining Company has a shaft that is down four hundred feet, timbered with steel, and I think they adopt that as being stronger. Mr. Drake, the chief engineer, is here, and can explain it.

MR. DRAKE: We haven't adopted the steel frame as a standard, but are using it in two shafts, one at the Pioneer Mine and the other at the Norrie Mine. The Pioneer shaft is a three compartment shaft, and the shaft at the Norrie is a four compartment shaft. They are lined with frames or sets formed of steel rails, thirty pound rails being used for wall plates, and twenty-five pound rails for end pieces. Three or four-inch I-beams are used for dividing pieces. The end and dividing pieces are connected to the wall plates by steel angles and riveting. The sets are placed four feet between centers, and have stuttles between them the same as timber sets. The stuttles are not riveted to the sets, but have a slot in their ends which holds them in place, the sets being blocked in with wooden blocking the same as timber. The steel sets are built complete on surface, and then are lowered into the shaft and wedged in place. The skip rails are afterwards bolted or riveted directly to the footwall plates. The Pioneer shaft is lagged with old wire ropes stretched longitudinally, five or six inches apart, between the steel frame and the rock. In the Norrie shaft the ordinary wooden lath are used.

MR. JACKSON: I refer to drop shafts. At the Isle Royale they sunk through the sand with steel caissons and afterward filled them with concrete and made foundations for the stamp heads. I would like to inquire whether the Pioneer shaft was in sand or rock.

MR. DRAKE: It is in rock. Rather hard rock. They are not intended to be used in very soft material.

DR. KOENIG: I should like to make a suggestion in employing iron or steel. It is largely dependent upon the nature of the material that a great many mines produce, not only coal mines but other mines, they carry sulphides. I should not think iron would be anything like safe or permanent under such circumstances.

MR. KELLY: The remarks of Mr. Drake are very interesting and it would be very desirable to have the structure detailed a little more. I think we all hope that

Mr. Drake will find it convenient to make detailed drawings and illustrate his remarks in the published proceedings.

MR. DENTON: Perhaps Mr. Drake will now give us a little more information with regard to the method of lining the shaft. I should like to hear the reason for using this steel lining.

MR. DRAKE: The considerations that determined its use were that it would be practically fire proof, and it would be durable, and could be removed in case the shaft was abandoned. These were the principal reasons.

MR. DENTON. How about the cost?

MR. DRAKE: It is about the same as timber, taking into account the less material to be removed on account of the steel members being narrow, and the total area occupied being considerably less than with timber. We estimate that the cost is about the same.

MR. MCLEAN: I assume from the remarks that Mr. Jackson made that he is of the opinion that steel sets are more expensive than the timber, and I would like to have him tell us how he arrived at the conclusion.

MR. JACKSON, That is a matter that I really haven't investigated very carefully. It may be one of the conclusions I jumped at without much figuring. I haven't made any comparative estimate sufficient to argue the point at all.

MR. POPE: I presume the objections made by Dr. Koenig is in regard to the early decay of the steel structure. But would the repairs be more than the required repairs of a wood structure under the same conditions? We can replace the decayed timber of a wood lined shaft without much trouble or expense.

MR. KOENIG: My suggestion has no reference to the cost of repairing. It was merely a chemical suggestion. It would be hard to see to what extent a piece of iron or steel brace or beam has been weakening. A stick of wood shows it more plainly and I should consider it was more dangerous. The same as in an iron bridge. It is more dangerous than a wooden bridge. A leaking out of the dissolving iron. I know iron and steel has been used in Europe for many years past, but only for very temporary supports, and being taken out quickly. Not anything permanent.

MR. DRAKE: I would say with reference to that suggestion, that in some of our mines on the Menominee Range, there is a considerable quantity of pyrite in the rock, and the action of the water on the rock brings sulphuric acid into the mines. We wouldn't consider at all putting in steel linings in this locality.

HISTORICAL SKETCH OF SMELTING AND REFINING LAKE COPPER.

BY JAMES B. COOPER.

Of the first two attempts to smelt (not refine) copper in the Lake district, I have found no published record. These were both made in Keweenaw county and Mr. John Senter has given me the following data regarding them: In 1846, the year Mr. Senter came to Eagle River, a furnace was built on the Gratiot river, a short distance west of the present main road. Prof. Jas. T. Hodge built and ran this furnace two very short campaigns. The selected rock, estimated to contain at least 20 per cent, copper, was the material smelted and the net result of the second run of this furnace was 6 per cent, copper. No further smelting was attempted after this disappointing result.

The second furnace was built (probably in 1847) by the Suffolk Mining Co. to smelt gray ore copper. This furnace was located about seven miles southeast of Eagle River. This ore was said to be so high in iron, and I surmise so low in copper, that it was impossible to smelt it in this furnace. Mr. Senter fixes the date of this furnace by his having attended its sale in November, 1848.

In 1849, the Ohio and Isle Royale Mining company built a furnace on Isle Royale, which was never put in blast.

The product of the Lake copper mines had to be shipped to smelting works already established in eastern states. Until late in 1848 probably all of this copper was smelted by two works—the Revere Copper works, of Boston, and the Baltimore, Md., works. During these years practically all the product of these mines consisted of mass and "kiln" copper as the calcined barrel work was called. The mass was an entirely new proposition to the smelters as the entire world's product of copper, with small exceptions, had previously been made from the ores of copper. All refining furnaces had the small sicle-door openings only for charging the ores or pigs of copper.

At the Baltimore works a large side-door opening was made and the masses were dragged into the furnace by chains passed across it and through a door on the opposite side to a windlass. The larger door was bricked up after the charging of the furnace.

The inevitable result of this method of charging the mass copper was serious damage to the furnace hearths though they were protected as much as possible with ore and wooden skids.

In 1848 Dr. C. G. Hussey, of Pittsburg, one of the directors of the Cliff Mining company, went to the Revere works to make arrangements for the smelting of their product. It is said the price asked was $80 per ton for masses. This rate was so high that Hussey and Howe, of Pittsburg, Pa., decided to build a smelting works.

CALUMET & HECLA SMELTING WORKS, LAKE LINDEN.

Their first experiment seems to have been made with the object of reducing masses to sizes small enough to charge easily into an ordinary side door refining furnace.

They placed the mass in an ordinary "cannon" furnace of the Fort Pitt foundry of Pittsburg, having first removed the arch or roof. This arch was then rebuilt and the mass finally melted and the copper tapped into sand beds.

The slow heating and melting of this mass evidently made an excessive quantity of slag high in copper. It is also said they suspended a mass by chains in a blast furnace and attempted to melt it. Result, broken chain and a demolished furnace.

However, in 1848, Hussey and Howe built a reverberatory refining furnace with a movable roof or cover; this cover being a little larger than the charging-hole in the arch of the furnace. This became the universal method at all works smelting Lake copper.

In 1850 J. G. Hussey & Co. built a copper smelting works at Cleveland, O.; they evidently expected to smelt all the copper they could secure, but in competition with the Detroit and Portage Lake works were not successful. Up to the time of closing this works in 1867 they had smelted very little except the product of the Cliff and National mines in which Hussey, Howe & Co. were heavily interested.

John R. Grout, the originator of the Detroit works, who had been in the Lake copper district, as stated in Mr. Pope's paper, decided that Detroit was the proper location for a smelting works for Lake copper. Like the others he tried the experiment of smelting rich rock direct in a cupola. This trial was made in the small iron cupola of the Smith foundry at Birmingham, Oakland county, Mich., where the old inhabitants still remember the characteristic red color of the slag from amygdaloid rock.

Mr. Grout went to Waterbury, Conn., which was then, as now, one of the great copper consuming cities of the United States. Four of the largest brass manufacturing companies furnished the capital necessary to build a works consisting of one refining furnace. These brass companies had had serious trouble in buying copper that was even in quality and equal to their requirements in alloys or in sheet copper where great tensile strength and elasticity were demanded. Their principal object in starting the works was to secure a brand of copper on which they could always depend. This smelting company was called the Waterbury and Detroit Copper Co. The Detroit works was completed and a small quantity (about 150 tons) of copper was refined in the fall of 1850. Here, on May 10, 1851, my father, James R. Cooper, began work and is now closing his 50th year of continuous refining of copper.

In 1860 the Portage Lake Smelting works was built directly opposite Houghton under the supervision of the Messrs. Williams. At this works they began refining copper early in 1861. It was well patronized by the local producers. The product of the Calumet & Hecla mines was sent to this works. They built one stack on the hill side back of the works and four of the refining furnaces were connected to this by an underground flue.

In July, 1867, the Portage Lake Works, with its better central location in the mining district, and the Detroit works, with its prestige as to brand of copper, were consolidated as the Detroit and Lake Superior Copper Company, with Mr. Grout as general manager. My father came to Houghton at this time as superintendent, and remained one year, returning to the Houghton works in October, 1873, and at the death of Mr. Grout in 1881, succeeded him as general manager.

Between 1860-67 two small works were built. One at Lac-La-Belle, Keweenaw county, by one of the Messrs. Williams in 1865. This was in commission only a few months of the year 1866. The second works of this period was built by Major Pont Alba at Ontonagon, and from about 1863 to 1867 was in commission.

From 1867 to 1877 the Detroit and Lake Superior Copper Company refined the entire product of lake copper except a small amount smelted by the Houghton rolling mills (the Lake Superior Native Copper Works), whose one refining furnace and cupola were put in commission in 1882. The mineral smelted at this works was almost entirely from small mines controlled by the owners of the rolling mills.

In 1886 the Calumet and Hecla Smelting Works at South Lake Linden, owned jointly by the Detroit and Lake Superior Copper Company and the Calumet and Hecla Mining Company, were built and smelting began June 1, 1887. The Detroit works were closed finally in January, 1887.

In 1888 the Dollar Bay Smelting Works were built by the Tamarack-Osceola Manufacturing Company, and smelted copper of the Tamarack, Osceola and other mines controlled by the same management. These were consolidated with the Houghton works of the Detroit and Lake Superior Copper Company in August, 1890, as the Lake Superior Smelting Company.

In 1891 the Calumet and Hecla Mining Company built the Buffalo Smelting Works where, since early in 1892, a large part of their product has been smelted.

In May, 1898, the Tamarack and Osceola Mining Companies bought the Lake Superior Smelting Company's works, thus, like the Calumet and Hecla Mining Company, acquiring their own smelting works but continuing to do custom smelting for other mines of the district.

In this same month, May, 1898, the Quincy Mining Company began the erection of their own smelting works on the stamp sands of the old Pewabic mill. J. R. Cooper supervised the construction of the Quincy works and continues in charge. Smelting was begun December 1, 1898.

This completes a hasty sketch of the various works to date. The continuation of the control of the refining of Lake copper by the management of the old Waterbury and Detroit Company is truly the survival of the fittest, and the reputation of the 'Lake" brand was made by them.

There is no doubt that the Lake copper properly refined is the only "Best" copper. The peculiarly tough quality which is characteristic of the native copper is retained to a great degree in the refined copper product. From the very beginning at the Detroit works to the present time this copper has been refined by the best known methods to retain in it all the good qualities possible.

In comparatively recent years the increasing use of copper for electrical purposes has added a new and most severe requirement, as the metal must now be refined so as to get the highest conductivity possible. The progress toward better and more even refining has been continuous, the variations in "set" now allowed being very much less than formerly.

The position of the smelting works in having to always stand for the quality of the "Lake" copper has not, I think, been fully appreciated by the mining companies. The smelting companies have always had to make good any losses caused the manufacturing company by a poor quality of copper.

Brief mention of a few of the claims made by manufacturers may be of interest:

One rolling mill, having a refining furnace of its own for the refining of scrap copper, made a claim that one large cake out of a number sent them had gone wrong. On inspection a difference in general appearance of copper sheet made from this cake and the other sheets known to be Lake copper led to the making of an analysis and a generous percentage of tin was found, this being direct proof that it was one of their own cakes made from tinned copper scrap.

At another time a piece of trolley wire was submitted to the writer, claim being made that the copper was not homogeneous. On examination a thin but heavily oxidized film of copper was found entirely covering the surface of the wire. On bending the wire, this film would separate and could be easily peeled off. This copper had been badly oxidized in heating or annealing through some fault of the furnace or the furnace man.

A claim was submitted to the writer while in charge of the Bridgeport, Conn., refinery for a roll damaged by a perfectly bright wire nail with one side of the head and the same side of the wire portion of the nail flattened. This nail had been found sticking in a rolled copper rod about ⅜ of an inch in diameter.

A careful investigation of this case developed the following points:

Point No. 1.—This nail could not have been in the molten copper or it would have shown evidence of contact with the copper.

Point No. 2.—The nail could not have been clinging to the outside of the copper bar in the heating furnace or the red heat attained would have oxidized its surface.

Then it must have been on the floor of the rolling mill and become stuck in the copper between the passes through the rolls.

At another time a piece of copper cut from the edge of a 30-inch circle, ⅜ of an inch thick, was returned to the smelting works as showing conclusively that it had been badly refined. This piece was approximately 3 inches wide in the center. On breaking it a distinct difference in fracture was shown at different points.

This was analyzed for sulphur, and three analyses, each representing about one inch, commencing at circumference of the circle, contained approximately two, three and four times respectively the amount of sulphur in the original samples of the invoice retained at the smelting works.

On visiting the rolling mill an oil furnace was found in use for heating. This furnace had worked too slowly to suit the heater who had been running it, so he removed a section of wall built purposely to prevent the oil-flame from striking direct upon the copper. The oil used was the crude Ohio article, high in sulphur, and with the flame striking the sheets direct, the copper had absorbed the sulphur. This is an interesting proof that copper will quickly absorb sulphur at a temperature far below its melting point.

One railroad casting shop sent in a claim for a 5 per cent. loss on ingot copper. They said the copper must be very impure, as a great quantity of slag formed in their crucibles. This was ignorance, pure and simple, as the copper was found to have been melted without charcoal in the crucible and without even a cover to protect the copper from the oxygen of the air and the sulphur of the poor coal used.

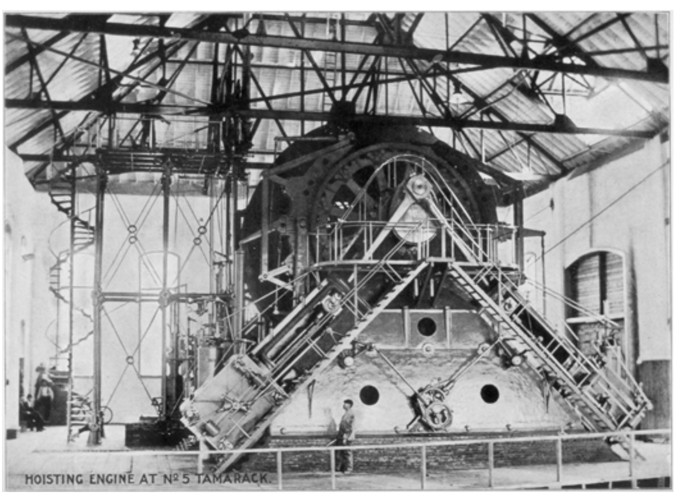
During this 50 years the refining of copper has passed from an imperfect process to an exact science. For many purposes the Lake copper cannot be successfully replaced by the electrolytic, its nearest competitor. For example, cartridge metal, which demands a brass of great tenacity and elasticity. I doubt if this brass can be made from any other brand than Lake and always be equal to the present government requirements; but for this very reason, better and more even refining will always be demanded of the Lake copper, as it has been in the past, for the manufacturer will use Lake for his best work where the tests demanded are universally high.

NO. 5 SHAFT AT THE TAMARACK MINE.

BY W. E. PARNALL, JR.

On the 7th of August, 1895, the work of preparing the ground, which had been selected as the site for No. 5 shaft, was begun. We cannot say that ground was “broken” as the nature of the soil was such that the term would not be applicable. The fact is, the site was in a swamp, which at that time compelled the men who entered it, to jump from hummock to hummock, to avoid a bath of mixed mud and water which they were sure to obtain if they by any chance stepped into the intervening spaces.

Long ditches were dug to carry the water away and a large area cleared of its growth of brush, allowing the sun to do its part in evaporating the moisture that could be exposed to its action, so that, in a few days, work could be done by men and horses with comparative ease and the actual work of sinking the shaft was begun. The first fifteen feet of sinking was through black vegetable mould which when dried was found to be excellent fuel for stoves or grates, and a considerable quantity of it was saved for that use. The drainage ditches which are mentioned above could only be dug deep enough to carry off the water from near the surface of this peaty deposit, so that the flow of water into the shaft was so great that it was deemed advisable to put down an auxiliary shaft or well, to drain the ground that the main shaft must go through, and handle all the water by pumps located in this well, thereby avoiding the troubles usually encountered in handling dirt and timbers in the openings partly occupied by pumps, pipes, etc.



HOISTING ENGINE AT Nº 5 TAMARACK.

The “drop shaft” principle was applied in getting the drainage well opened to bed rock, except that, instead of timber “sets,” a circular curb was used. It was constructed of rings formed by building up segments cut out of 2 inch plank and faced on their periphery with two by four spiked to the rings, so as to make sections about seven feet long which could be bolted together one on top of another, as the sinking progressed. These curbs were light, easily handled and answered the purpose admirably. Their form made them very rigid although composed of small pieces of lumber, and for the ordinary depths where timber sets are generally used, these curbs are a cheap and convenient substitute, which do away with the necessity of framing large pieces of timber and fitting them together under the usual severe conditions. The “drainage well” was located a few feet away, so that it did not interfere with the removal of dirt or placing of timber in the shaft. When the water was drained out of the peat deposit it was not difficult to excavate, as the workmen could cut it into convenient pieces with their shovels, and then handle it either with the shovels or their hands as most convenient. The peat was underlaid by about five feet of good gravelly hardpan which lay directly upon the bedrock. It was therefore unnecessary to do any timbering until after the rock was exposed for the full size of the shaft. The overburden was taken out to allow room for a timber cribbing outside of the main shaft cribbing, and a space of 18” between. This space was floored with clay and cement forming a guttering that carried all the water from seepage through the overburden and some small streams that were found running on the surface of the bedrock, into a tunnel connecting the shaft with the drainage well already mentioned, where the pumps could take it and force it to surface.

After levelling the surface of the rock to form a good bed for the timber, the double cribs were put in after the usual plan, and sinking in the rock begun. The men employed at this shaft needed but little instruction as to the best way to proceed with their work as they had already learned by experience at other shafts sunk at Tamarack how to break the ground, handle the dirt, set the timber, etc., to the best advantage.

They were capable of making good progress from the start if supplied with the proper equipment, but as is usually the case, a temporary plant of the portable type had to be used for some time, until the larger engines could be installed. We find, therefore, that on Jan. 1, 1896, or nearly five months after work was begun, the shaft had reached a depth of only 140 feet. Still those who have been through the experience of sinking shafts and at the same time equipping for doing the work, can readily appreciate these figures and will agree that it was a pretty good record.

Experience with other deep shafts at Tamarack had taught, that it was poor economy to limit the shafts to small dimensions, because of the unsatisfactory apparatus that could be used in them, when it came to a question of operating. No. 5 was, therefore, laid out on a more liberal scale than any of the others. It contains five compartments, four of which are for two pairs of balanced cages to operate in, while the other is for ladders, pipes, etc. The cage compartments measure seven feet, two inches by five feet two inches, inside of timbers, except the one on the eastern side, which is seven feet two by five feet, two. The pipe and ladder compartment measures seven feet, two, by three feet. The idea of making the eastern compartment two inches larger in one dimension than any other compartment having the same work to do, is explained as follows: The long axis of the shaft is approximately at right angles to the strike of the formation. The angle of dip of all the strata through which the shaft is sunk, is approximately 38 degrees. It is but natural, therefore, that the timbers which have the most pressure exerted against them because of these conditions, are the end timbers in the eastern end of the shaft. Some of the rock strata when freshly broken seem solid and homogeneous enough, but, after exposure to the air for a considerable time, develop a tendency to swell and blister off in large blocks which slide away from their beds and exert considerable pressure on the shaft timbers. It becomes necessary to replace or strengthen the timbers sometimes because of this action, and the two inches of additional width in this compartment will allow this to be done to much better advantage than it could be in a compartments limited in size to actual requirements for operating.

The timbers used have the following dimensions:

Wall plates, 10 inches by 14 inches by 20 feet 2 inches.

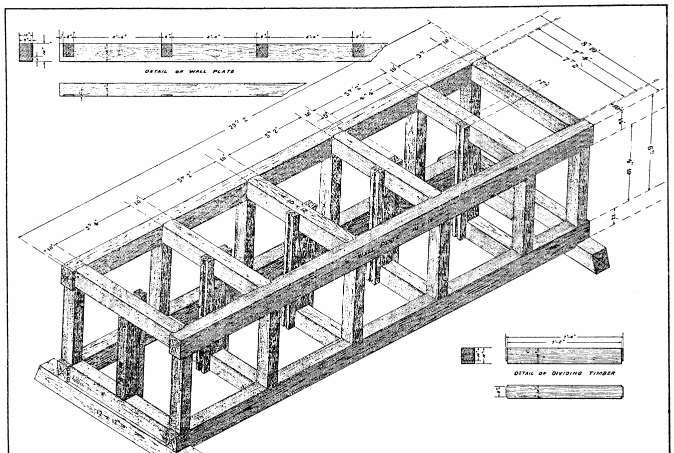
Dividings and end timbers, 10 inches by 12 inches by 7 feet 4 inches.

Studdles, 8 inches by 10 inches by 4 feet 10 inches.

Runners, 5 inches by 7 inches by 16 feet to 22 feet, grooved as shown in cut 2 inches wide by 1½ inches deep.

The object of the grooved runners is to prevent a loosened or broken lag screw from binding between the cage and the runner. This occurrence, in shafts where the runners are merely counterbored to allow the lag screw head to set below the surface of the runner, usually proves disastrous to either the cage or a considerable length of runners, sometimes both. With the grooved runner the lag scraw has a chance to drop out of the way when struck by the cage. Details of the method of framing the shaft timbers are shown in the cut. The plan shows no radical departures from the usual methods of shaft timbering except the grooved runners mentioned above.

The outside dimensions of the timber sets are 29 feet 2 inches by 8 feet 10 inches, so that the smallest opening in the rock which would allow this size set to be put in would contain 261 cubic feet per foot of depth. In trap rock this would amount to 20 tons of broken material. It was estimated that an average of about 85 feet per month could be sunk. The hoisting equipment must therefore be capable of handling a daily output of about 70 tons of rock, besides the timber, men, supplies and tools.



Shaft Timber No. 5 Tamarack

An engine which had already done service in another capacity was fitted with two drums, each having a capacity of 3,000 feet of 1⅛ inch rope, and went into commission about the last of December, 1895.

This improved the conditions so that in the month of January, 1896, the amount snuk was 52 feet. During the year 1896 the total amount sunk was 846 feet, or an average of 70.5 feet per month. Two pump stations and sumps were cut and the necessary pumps installed.

The total cost of sinking and timbering the 846 feet was $70,324.06, or an average of $83.13 per foot. In the year 1897 the total sinking was 1,029 feet, or an average of 85.75 feet Per month. Three sumps and pump stations were cut during the year. The total cost was $88,635.07 or an average of $86.14 per foot. In 1898 the the total number of feet sunk was 985 or an average of 82.08 feet per month. The total cost for the year was $83,530.38 or an average of $84.80 per foot. In 1899 the total number of feet sunk was 918, or an average of 76.5 feet per month. The total cost was $97,147.55, or an average of $105.83 per foot. In 1900 the total number of feet sunk was 762, or an average of 76.5 feet per month. The total cost was $101,545.10 or an average of $132.17 per foot. During the year 1900 five stations or plats 25 feet long, 18 feet wide, and averaging 11 feet high, were cut.

In preparing these figures no allowances have been made for time consumed in cutting pump stations, sumps or plats and the cost of these items has been charged directly against the number of feet the shaft was sunk during each year.

The items which appear on the cost sheets from which the figures of cost as given are derived are as follows: Captain and assistant, timbermen, machinemen, bucket fillers, engineers and firemen, landers, smith, carpenter, machinists, team, etc., powder, fuse and caps, oil, candles and wick, wire rope, hardware and iron, pipe fittings and machine parts, lag screws, nails and spikes, lumber, timber and lagging, engine house supplies, and fuel. All these charges are made directly against the shaft, and a separate account of equipment and construction of all kinds has been kept.

Four Rand machines of the "slugger" type were used to do the drilling which usually amounted to 44 holes from four to six feet deep, in 24 hours. These holes would usually "draw" and "square'' a five foot "cut" or "sink." It has been customary to take out a wedge shaped "sink" as the Cornish miners usually call it, across the center of the shaft and then stope out the ground from the "sink" to the ends of the shaft in two separate underhand stopes. The details of the method were as follows: Suppose the bottom of the shaft had been "squared up" or levelled. The first shift of miners would set up their machines and drill the holes which, when blasted, would break out the ground in a wedge shaped "sink" across the short axis of the shaft. When these holes were drilled, they would drill as many as possible of the "stope holes" which would be arranged for taking out the ground from the center to one end of the shaft. They would blast both the sinking and the stoping holes at the end of their shift. This blasting would break all the ground in one end of the shaft and leave a bench or "slope" in the other end which of course would now be covered more or less with the broken dirt. The fillers would then go down and begin the next shift's work by cleaning up from the end of the shaft that had not been drilled or blasted. As soon as they had exposed the solid ground there, the miners would rig up their machines and begin drilling so that, when the fillers had cleaned up all the broken rock in the shaft, which was usually done in 7½ hours, the miners would have more than half of their shift's drilling done. The fillers were then allowed to leave the shaft and go home. The miners would continue drilling until within an hour of the end of their shift, when they would take down their machines and blast and all would be ready for the fillers to begin cleaning out the dirt again. This program would indicate that five feet of sinking would be done every 24 hours. This of course was not the case because it frequently happened that the work of timbering the shaft, trimming off protruding masses of rock or securing bad ground by temporary timbering, would interfere and delay, any, or all of the operations mentioned. After blasting had been done, a timberman of experience always examined the shaft and passed judgment upon its condition before any work could proceed. If he found any indications of the place being unsafe to work in, he would have it made secure by trimming, timbering or whatever he deemed necessary before the fillers or miners were allowed to begin their work.

A full complement of men for the work in the shaft consisted of 22 miners, 14 fillers, 10 timbermen, and two pump tenders. These were divided into two crews for night and day shifts so that 24 men were at work on each shift. The surface force consisted of landers, laborers, hoist engineers, compressor engineers, firemen, blacksmiths, etc. The number of men on surface varied from time to time to suit requirements. Usually there were more employed in winter than in summer.

A competent mining captain or foreman had supervision over all labor which was directly chargeable to the shaft sinking. He had an experienced timber boss and two shift bosses under him, who gave their attention to the timbering, drilling and blasting operations. All work was done on the company account system which, with good supervision has been found to be productive of the best results in this branch of mining under the conditions existing at the Tamarack.

Great care was always exercised to have the conditions for the comfort and safety of the men as perfect as possible. In this the management was guided by the experience already gained at the other shafts and the record of accidents has been an extremely small one. Only two fatalities occurred, both of them being caused by rock falling out from the ends of the shaft after having been examined and considered safe. Considering the number of men employed and the variety of strata sunk through this is a good record. In fact we know of none better. No serious accidents have occurred which can be traced to faulty apparatus or methods. This has been largely due to the fact that safeguards had been provided to prevent such accidents as had been met with in sinking the other shafts, and the apparatus employed seemed to meet all requirements. An inspection of the cuts will show the provision for keeping the shaft covered at all times so that nothing could accidentally fall into it from the surface, which has heretofore been one of the great points of danger. This piece of apparatus was devised at the Tamarack and has been used for several years giving entire satisfaction. No description seems necessary as all its features may be understood and appreciated by simple inspection which will not only show how the shaft is covered during nearly the entire time but also illustrates the method of landing the buckets and handling the waste rock on surface. (See fig. 1, 2, 3 and 4.)

The buckets used hold 1⅝ tons of broken rock and the ropes used to hoist them were 1⅛ inch crucible steel sinking: topes with steel core. This size was used until a depth of 3,500 feet was reached. After that 1¼ inch ropes of the same type have been used.

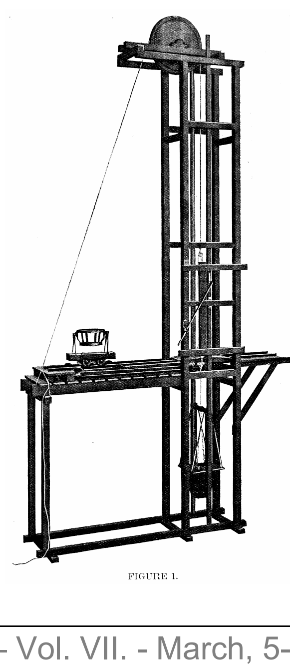


FIGURE 1.

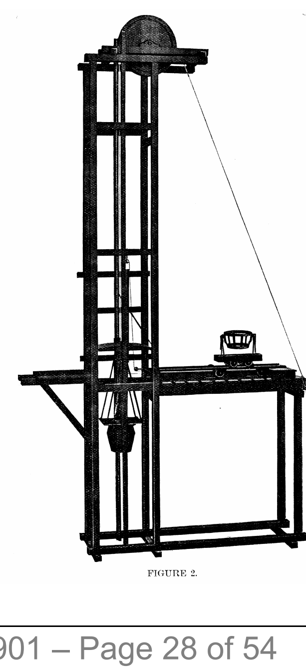


FIGURE 2.

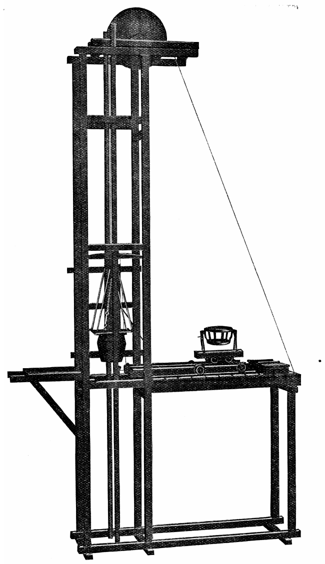


FIGURE 3.

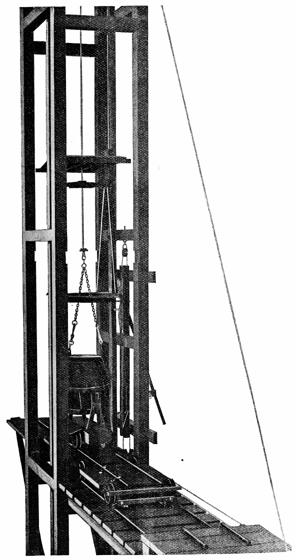


FIGURE 4.

During the early days of sinking deep vertical shafts it was customary to use buckets similar to those now used, but suspended a few feet under an iron or wooden crosshead which ran on guides in the shaft and which was intended to keep the bucket from swinging and striking the timbers or sides of the shaft. Such an occurance would of course be a source of great danger. This combination worked well enough for moderate depths or within a limit of about three thousand feet and was the plan used entirely in sinking shafts Nos. 1 and 2 at the Tamarack. In sinking Nos. 3 and 4, however, which went below the limiting point it was found that when the shaft went deeper the cross head was entirely unsuitable. In fact further progress would have been impossible. A new problem arose. As is well known by men who have had experience with wire rope, a rope traveling over sheaves and hanging with one end free, will twist more or less every time it makes a trip through the shaft. Ropes made with a steel core which is twisted in the opposite direction to the strands on the outside and commonly called sinking ropes, are much less liable to this twisting action than ropes of the ordinary type, but even they are subject to enough to compel means to be adopted for neutralizing the effect when three thousand or more feet of rope is suspended in a shaft. It seems that at this point the twisting becomes great enough to set up a gyroscopic action and in No. 3 shaft, when this action was not restrained, it was sufficient to cause the bucket to assume a position so nearly at right angles to the rope as to dump its contents. This actually occurred and was the reason for devising the cage as shown in the cut, to replace the crosshead.

The cage has been found to be a satisfactory apparatus and has been used at No. 5 ever since the shaft started from surface. The cage is held up from the bottom of the shaft by blocks fitted against the runners and as the rope merely passes through the cage without being attached to it the bucket and rope can continue their descent after the cage has come to rest on the blocks in the same way as formerly when a crosshead was used.

The space between the permanent shaft timbers and the bottom of the shaft varies from day to day. It is seldom less than 20 feet and often more. The bottom of the guides upon which the cage runs is frequently 40 or 50 feet from the bottom of the shaft and, of course, the cage cannot be allowed to go below its guides so that the bucket and rope travel through this space without the cage. The workmen take advantage of this condition by swinging the slowly descending bucket and causing it to land on the bottom in a place that is convenient for filling. Two buckets for each hoisting rope are used so that one maybe filling while the other is in transit. When the men have disconnected the rope from the empty bucket and attached it to the full one the signal is given to the engineer who hoists only far enough to suspend the loaded bucket above the bottom. The fillers then steady it until there is but little swaying motion and a new signal is given the engineer, who then hoists it to surface.

The various strata pierced by this shaft are shown in cut "C" which is a cross section at right angles to the strike of the formation. The strata may be classified under three headings, viz.: Traps, amygdaloids and conglomerates. The various belts of trap differ but little in appearance or characteristics, except that some show the jointed formation to a greater extent than others. The amygdaloid belts were usually firm and hard. They stand exposure to the air without much tendency to blister and require usually a minimum amount of timber.

No. 5 Shaft was begun Aug. 7, 1895.
Calumet Conglomerate struck on December 20, 1900.
Average monthly sinking entire depth 72 3.

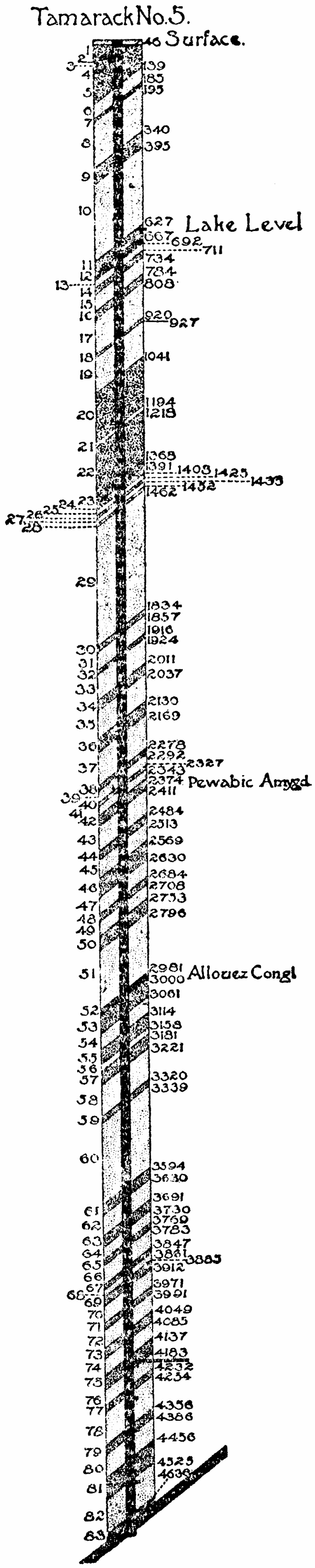
	1895	1896	1897	1898	1899	1900
Highest monthly sinking		98	100	90	84	84
Lowest monthly sinking		43	64	72	57	29
Average mohthly sinking	28	70	86	82	76.5	63.5
Total yearly sinking	140	846	1029	985	918	762

Collar No. 5 is 604 44 above Lake Superior.
Calumet Conglomerate struck at 4657 below collar.

29	level	plat,	4162.43	below collar.
30	"	"	4279.20	" "
31	"	"	4378.70	" "
32	"	"	4559.68	" "
33	"	"	4541.54	" "

The conglomerates encountered possessed the well known characteristics of Keweenaw conglomerates and no copper, or at best only traces, except the belt that is responsible fox this great undertaking about which I have written, viz.: The Calumet conglomerate, which was reached by this shaft on December 20th last at a depth of 4,662 feet and which was found at this point mineralized to a degree which, if maintained throughout the openings that will be tributary to this shaft, will undoubtedly return the money invested.

CUT C.



DISCUSSION OF MR. PARNALL's PAPER.

MR. THOMPSON: I understand from the description of the shaft, that it was covered most of the time. I would like to ask if they had any difficulty in ventilating the shaft.

MR. PARNALL: I neglected to add to the paper anything on that subject. In fact I hadn't thought of it before. I will do my best to try to explain now the method used. This model only represents one compartment. On one side was a close board casing in the shaft house. Of course the air was free to enter the shaft at the level of this floor wherever the opening was made for it to go in, and of course there were openings purposely kept. On the other side a close casing would run up to a height of about one hundred feet which made a difference in the two air columns and caused the only ventilating drafts used at any time. There were none other than the natural means. The opening and closing of this door did not interfere with the ventilation in any way, and the opening to supply the fresh air was through this door.

MR. FITCH: I would like to ask whether the men suffered from bad air. Was there any delay on that account?

MR. PARNALL: No, sir, no delays on that account in this shaft.

MR. POPE: I would like to ask how soon after the fillers left the blasting was done.

MR. PARNALL: At the end of the miners shift, so that one hour intervened between the time of filling and blasting.

MR. FITCH: I have always found that the gases from the powder would settle in the shaft, so that even if the shaft was left for a month those gases would be found at the extreme bottom and would remain so. It might be explained, then, that the air discharged from the drilling machines or the rapid hoisting was sufficient to relieve the shaft of the gases.

MR. PARNALL: I might say that the miners usually turn on a little fresh air to blow out the smoke a little quicker than it might go of its own accord. There was enough natural air, however, to start them up without. The powder used was an ammonia powder, and while the fumes are disagreeable, we found that after one hour's interval, men could go down and work without any difficulty whatever.

MR. FITCH: We find that our muckers in working up the dirt release a good deal of this gas and we are troubled with it. Any ventilating plan would be insufficient to beat the gas out of the dirt. It must be that it is more on account of this peculiar powder that you use that the character of the gases are modified. I have never heard of that powder and I suppose it is specially made for that work.

MR. PARNALL: I don't know for shaft sinking purposes but in poor ventilation it is excellent.

MR. FITCH: Made by what Company?

MR. PARNELL: That we have used is made by the Hancock Chemical Company of Dollar Bay.

MR. FITCH: We have found a great deal of trouble from bad air, even after the mucking has been completed, in rigging up their machines the miners would at times be overcome.

MR. PARNALL: The stirring up of the gases that you have mentioned has been noticed in Tamarack, but not enough to prevent the men from continuing the work. A small percentage of the men were interferred with by the gases and compelled to leave their work. It must have been due to the gases. The only natural assistance was, however, the operation of the drills.

CAPTAIN PARNALL: I would say that in sinking a vertical shaft through water, the water itself would modify the gases to a very large extent, and I think that has helped very largely to eliminate the difficulties Mr. Fitch speaks of. We certainly feel the advantage of the powder described by Mr. Parnall over the ordinary glycerine powder. But having the fresh powder made and the difference in the balance of the air columns that he has also explained, by which we always had a good current, added with the amount of water dropping constantly, killing the gases, rendered it possible to let the men work at all times.

MR. FITCH: This explanation probably covers the ground and would make it clear why in our mine we are troubled more than in some of the others; as in our case the shafts and drifts are perfectly dry.

MR. PARNALL: I might say for Mr. Fitch's information, that the water that occurred below the 1200 foot point was a nominal amount. We sometimes sent water down for killing the gases. It was a small amount. This water was taken up with the rock and hoisted as so much waste material. The amount of water was extremely small.

MR. POPE: You stated that they turned on some air. Did they do that before the blasting?

MR. PARNALL. They suited their own convenience. Usually afterward.

MR. POPE: In the great crosscut 2400 feet long in the Franklin Junior, we had satisfactory results by using the same kind of powder described by Mr. Parnall. I don't think it is as strong as the Marquette powder. I don't think the 45% is as strong and doesn't keep quite as long.

MR. PARNALL: We use the 50% grade.

MR. POPE: In the great crosscut there was a three-inch pipe carried along the top of the drift and the miners connected that to the drill with the ordinary hose. They opened the valve just before blasting and got as much air as needed, and sometimes they turned on a little more than was needed. There was a constant flow of water and it was always leaking out through the heading. That three-inch pipe gave them perfect air always, except when they returned to their shift they would meet these gases part way and pass through that and find good air beyond.

CAPTAIN PARNALL: With ordinary black powder, there is not a miner that has worked in a drift that does not know a wet drift always modifies the gases. As a boy I worked under ground using only black powder, but where we had plenty of water in a drift there was never any danger going in for fear of the gases, so evidently the water neutralized the gases even when we had to use black powder.

MR. FITCH: I was going to say we use 65% powder, and in that we generate a large amount of gas.

MR. POPE: Do you generally use 65% powder?

MR. FITCH: In all our shafts and drifts; but not in stoping.

THE CRYSTALIZATION OF MOHAWKITE, DOMEYKITE AND OTHER SIMILAR ARSENIDES.

BY DR. GEO. A. KOENIG.

I venture to call attention to a matter of purely scientific interest and beg to ask your indulgence. In order to obtain a thorough scientific knowledge of the very interesting mineral which I described a year ago under the name of Mohawkite, it was necessary to prove its relation to the mineral domeykite. The latter substance has been known for many years from several localities in Houghton county, and lately its occurrence has been noted in great quantity at the Mohawk mine in Keweenaw county. In none of these occurrences, however, have any crystals been observed, just as the face characterizes the individual man, so the crystalized form characterizes the mineralogical individual, the mineral species. Until this crystal form is known, it cannot be said that a mineral species is well established.

From the analysis I deduced the composition of Mokawkite as being a domeykite in its molecular mass of three atoms of copper to one of arsenic but so that of those three copper atoms a part is replaced by nickel and cobalt. Dr. Ledoux, of New York, on the strength of his analysis, made out the formula for Mohawkite as being four copper atoms to one of arsenic, with part of the four of copper replaced by nickel and cobalt. Being thus placed upon the defensive, as it were, it became necessary that I should prove the correctness of my deduction against that of Dr. Ledoux. I argued that the best means of proving my position would be to make crystals of both domeykite and Mohawkite, and if these crystals showed identical forms together with an identical molecular structure, then the correctness of my position would be proved.

I have here on this table for your inspection a number of preparations which are the result of the experiments instituted in pursuance of the above argument. These experiments show that it is possible to grow exceptionally fine crystals of the two mineral species by acting, at the proper temperature, with the vapours of arsenic upon either pure copper or upon alloys of copper, nickel and cobalt. The crystals appear mostly as six-sided plates with beveled edges, bright, smooth faces, of dark grey color, and bright metallic lustre. But we also find crystals of prismatic and of pyramidal build; either of those forms being merely the super-impositions of the six-sided plates mentioned. When the plates are of the same diameter the prism results; if they are of decreasingly small diameter, pyramids result.

I have submitted some of these crystals to Prof. Grouth, of Munich, a recognized authority on crystallography. He pronounced them pseudo hexagonal, i. e., having the angles of the hexagon but not the symmetry of the hexagonal system. The crystals are probably orthorhombic triplets, as revealed by the etching of their faces with nitric acid. The isomorphic nature of the domeykite, the pure copper arsenide, and the Mohawkite, the arsenide in which part of the copper has been substituted, is established beyond doubt.

I have, furthermore, replaced part of the copper by silver, from two to fifteen per cent, of the latter, without change of either form or molecular structure. I have also substituted part of the arsenic by antimony, up to 10 per cent, of the latter, without change of either structure or form, except that in this case the crystals have a strong tendency to build up in acute pyramids rather than in plates. It is always the molecule with three atoms of metal to one atom of non-metal. In no case has any combination of four atoms of metal with one atom of non-metal been observed.

The series of experiments are as yet incomplete, although I have experimented with pure silver, pure lead, pure nickel, pure cobalt and pure zinc. The behavior of the silver in the presence of vapours of arsenic is especially noticeable. The arsenide forms rapidly, but it melts at once at a temperature below dull red heat, the temperature of formation seems to be near melting point under ordinary pressure. It remains to be seen whether under increased or decreased pressure crystallization can be produced.

Another interesting feature was the observing of a selective action on the part of the arsenic. If the arsenic acts upon the alloy of copper and silver or copper and nickel, the two metals do not enter into the crystals in the same ratio as contained in the alloy; the copper always predominates. Thus it has been seen that, given the choice, the arsenic first takes copper, then silver, then nickel.

I have a notion at present that with more extended experiments it will be possible to establish an exact numerical ratio for the rate of motion by which the force of crystallization compels the molecules to move. Much time and labor are needed for this kind of work, but it is this work only which can throw light upon those questions which alone it seems worth while to unravel; that is, which throws any clear light upon the inside of things.

You see here on the table the simple contrivance by means of which these results have been obtained. It consists of two glass tubes, around each being coiled a thin platinum wire. In the apex of the hard fusible glass tube is contained the arsenic. This is held in place by an asbestos plug. In the space before the plug the fragments of copper or other metal or alloy are placed; then comes a second asbestos plug; the open end of the tube is furnished with a mercury trap to prevent an air current from entering the tube. The second coil around a larger glass tube acts as a resistance; by simply shifting a piece of stout platinum wire to various parts of the two coils, I am enabled to maintain in the acting tube a very even temperature for any length of time, provided that the electric current remains constant. It is also possible to change the rate of temperature within very narrow limits, as well as wide limits, which is quite impossible with any other system of heating. In my first experiments I heated the converting tube in a gas stove, an Erlmeyer combustion furnace, with very poor and, in fact disheartening results. The device, as you see it here before you I call the crystal incubator, because the range of its adaptability is much wider than the present series of experiments. I trust, in fact, that I shall prepare tellurides, selenides, antimonides and sulphides by its means.

A CAUSE FOR INACCURACY IN COLORIMETRIC COPPER DETERMINATIONS.

BY DR. GEO. A. KOENIG.

The colorimetric has fallen into disuse to a large extent, owing to the substitution of electrolytic processes. In part, the cause may have been uncertainty in the values obtained. The usual execution of the colorimetric method is, shortly, as follows: A gram sample of the tailings, or other poor copper rock, is finely ground and digested or boiled with nitric acid for 15 minutes. Water is then added, say 25 cc. The solution is made ammoniacal; the precipitate filtered off, and the filtrate diluted in a suitable test tube to the standard volume. The intensity of the blue color of this liquid is then compared with another test tube containing a known quantity of copper. The clear solution in its purest form is purplish blue.

Now it happens every once in a while, and it so happened to some of my old pupils, that two samples taken of the same stuff do not at all agree. The one in fact is pale, the other may even show a greenish shade of color. It would at once seem reasonable that one could not compare satisfactorily with the purplish blue.

Now, what is the cause of this? I must confess that although I knew of the difficulty, I have let it slide and when pressed by the students for a reason, I explained it by the fact that probably a basic iron compound must be at the bottom of it. This I did, without giving any concentrated thought to the matter, until the present season when the colorimetric copper test came once more before the class. It did not take long then to explode the notion of the iron salt, because one of our local tailings yielding the green solution would not show any trace of iron. Then the idea occurred to me that possibly the coloring matter of the wood had something to do with this. The tailings must necessarily contain minute fragments of wood from the operation of the launders and other wooden parts of the machinery with which they came in contact. If this hypothesis be true, a thorough destruction of wood particles by oxidizing heat must afford a remedy, and it did remedy the difficulty at once. Then in pursuance of this idea it occurred to me to combine the solution of copper with the destruction of the wood fibre by fusing the sample with potassium hydrogen sulphate. This fusion does not take more time than the digestion with nitrate acid, in fact it is shorter. On the other hand, this fusion decomposes the silicates of the gangue more thoroughly than nitric acid, hence ammonia causes a heavier precipitate. This precipitate always retains a certain amount of copper. By numerous trials with tailings in which the copper had been absolutely determined, I have found that for our average gangue rock, and within the limits in which the copper percentage of tailings run, the precipitate retains very nearly one-fifth of that copper which is indicated by the colorimetric test.

It is therefore only necessary to add 20 per cent, to the copper which has been found colorimetrically, in order to obtain an absolutely accurate result in far less time than any other method could possibly furnish it.

The pale color of the ammoniacal copper extract derived from the nitric acid solution I have experimentally proved to be due to the presence of a certain amount of that yellow coloring material contained in the wood and which becomes more yellow in presence of ammonia; because this yellow produces with the blue a certain amount of green and the green is complementary to the red or the purple, and hence it follows that upon the addition of this yellow to a fine purple blue color the latter assumes a pale sky-blue appearance, and if now more yellow is added the solution turns into a greenish hue. Compared with the standard copper solution it must show very much less copper, in fact, sometimes less than 50 per cent, of the correct amount of copper.

With the precautions and modification that I have above proposed, I do not hesitate to commend the colorimetric method as the very best thing to control the tailings of a mill, or, for that matter, the copper contents of a slag.

DR. KOENIG'S SECOND PAPER OPEN FOR DISCUSSION.

MR. HEATH: I would like to ask Dr. Koenig if he tested slags from any of our furnaces.

DR. KOENIG: Yes. The slags can be decomposed in the same way, only it is not necessary. There is nothing in the slag which will produce the same greenish effect. You can decompose the slag with any method.

MR. HEATH: We do not always like to tell the story on ourselves, but I stumbled upon a similar experiment to the effect of organic matter making a green color. Most of you know that drugs of various kinds are sealed with paraffine, and this was carried into the analysis and the organic matter of the paraffine gave the same color.

THE TESTING AND CONTROL OF THE PRODUCT IN A MODERN COPPER REFINERY.

BY GEORGE L. HEATH.

Our members of the Institute here present will recognize, on bringing it to your attention, an important difference in the treatment of the mineral products of the iron districts and those of the copper regions of Michigan or Montana.

The raw iron ore is sent towards the fuel supply, near which are the iron furnaces, but the copper companies not only mine, but melt and refine, most of their mineral product into finished merchantable forms. This radical difference in the two industries renders it necessary that the copper smelters, either in Michigan or the Rocky Mt. districts, shall not only assay their raw supplies of native copper or ores, and fuel, but shall test the finished metal by a variety of accurate chemical and physical tests, such as in the iron business are only necessary at the Eastern smelters. At the same time a control must be kept of the small, but unavoidable, metallurgical losses that they may never exceed certain limits which have been set by long experience as “good practice.”

A special factor, unimportant to the iron worker, enters into copper metallurgy which renders the elimination of all traces of deleterious foreign substances from the copper, a problem of highest importance both to smelter and consumer. I refer to its property of high electrical conductivity. As the great carrier of unseen energy around the world, the copper used for any electrical work must be exceedingly pure, for very slight traces (even 0.002 per cent.) of some foreign elements (such as iron, sulphur, arsenic, antimony, bismuth, selenium and tellurium), markedly lesson the ability of copper wire to conduct the electric current. A metal should be produced also which can be made of uniform quality, on which the consumer may depend for the same results from the same mechanical work done upon it.

As the copper in the lodes of the principal mines in the Lake region occurs as filaments, grains, or masses of native metal free from sulphur, the methods of assaying are different in some respects from those adapted to the ores of the “Far West,” where the metal is generally concealed from the eye in a combination with pyrite and other minerals.

Such raw ores have to be mined, milled, smelted into matte, bessemerized, more or less refined, and the resulting copper cast into anode plates and put through an electrolytic treatment to purify the copper enough to fit it for electrical work. That the recovery of the gold and silver then pays frequently a considerable profit above the cost of the electrolysis is only an additional benefit from a necessary operation.

Lake smelters, however, have the much simpler problem of refining mill concentrates of native copper with a little self-fluxing ferruginous gangue, but with no more than a trace of sulphur. These concentrates yield, by one fusion in reverberatories, the greater portion of their copper contents, ready for direct refining and casting and a balance of rich slag which is re-melted in a cupola with limestone flux. The molten copper is refined by the two well-known operations; 1st, Rabbling, by which the copper is made to take up oxygen from the air to remove traces of impurities. 2nd, Poling with green wood, by which the oxygen is burned out again, and the metal rendered tough and fitted for casting. Hand rabbling has been superseded by the use of compressed air at several refineries with beneficial results.

The majority of the mines in the far West start, on the other hand, with a more or less impure assortment of ores, and work up by the series of treatments mentioned, to the high grade refined metal. Any slip in this series of operations must result in leaving in the finished product an undue amount of the impurities present in the original ore.

That the commercial product from ore is so good as it is today, speaks highly for the progress of modern metallurgy.

The various methods of control on copper and its ores may be divided into two groups:

A.—Assaying (or determination of special metals) in ores, mineral concentrates, slags and mill tailing's.

B.—Chemical, mechanical, and electrical tests on the metallic copper resulting from the melting and refining of the raw material. Under A we have

A. ASSAYING FOR COPPER (AND ASSOCIATED METALS.)

ON LAKE SUPERIOR.	IN ROCKY MT. DISTRICTS.
1. In mine rock.	1. On raw, and roasted ores.
2. In mill concentrates and tailings.	2. The same as in A.
3. In rich Reverberatory furnace slags.	3. In rich slag furnace, reverberatorics, re-melting cupolas, and converters.
4. In waste slag from slag re-melting cupola.	4. In poor slag from ore cupolas, etc.

A. I.—The low grade vein rock of Lake Superior mines is well understood to carry the native metal in particles of such uneven size, so unevenly disseminated in the lode and widely scattered that any valuation of a mine, or even a stope, on anything short of a mill test of 100 to 500 tons, is of no real value. Even if the copper were evenly disseminated, a sufficiently large sample could not be tested very accurately in a laboratory, as it is so low grade, and the particles of copper flatten without grinding up.

By grinding several pounds with repeated siftings, picking out and weighing up the shot left on each grade of sieve and then fusing ¼ to 1 pound of the last siftings in large crucibles, an approximate test may be made.

2d.—The concentrates produced by our stamp mills are, however, very easily and correctly assayed by the Lake Superior Fire Assay, described first in print by Mr. M. B. Patch (1) and later by the (2) writer in improved form. This method is the rule at all refineries of Lake copper.

After mineral has been weighed and dumped at the furnace ready for charging, it is shoveled over and small samples taken with a little cup and put in a tightly covered copper can. After all furnaces are charged, the assayer's assistant makes the rounds with a set of large cans. The different grades of mineral are collected and taken to the laboratory for assay.

This process can only be used for native copper containing no more than a trace of sulphur.

Even the cream of tartar, bi-carbonate of sodium, and borax glass, used as fluxes, must be quite free from any compounds of sulphur.

This fire-assay is made on 1000 Troy grains of mineral which secures a far better sample on this coarse material, than would be possible in wet methods of analysis.

By some, the method has been criticised as inexact but such criticism is due to insufficient practice and experiment with the assay.

In the hands of any good assistant, who has had at least a month's practice on different grades of material, it gives results which check from month to month the weighed output of the large refining furnaces and cupola, adding the slight loss of copper in the waste slag from the latter furnace.

The assayer mixes the weighed mineral with appropriate fluxes in proportions which have been ascertained by experience for each grade of material.

(1) Peter's Modern Copper Smelting.

(2) Engineering and Mining Journal, April 20,1895, page 389, 387.

We run rich concentrates (over 40% Cu) with such an amount of cream of tartar as reducing agent, that the loss of copper in the slag formed (about 25%) shall be balanced by 25% of metallic iron reduced into the copper button. Low grades are run with a little less reduction, yielding a pure button, and a slag containing about 0.35 to 0.4 per cent copper, the exact amount being determined by a quick color test, and added to the weight of button to get the total copper contents.

Mill tailings are too low for very accurate fire assay and are tested by dissolving the copper from the weighed sample of 1.0 to 10.00 grams with dilute nitric acid (1 part of acid 1.42 sp. gr. and 1 part water by volume). Sulphuric acid is then added (as indicated in another paper just referred to (2)), and the copper deposited on a weighed platinum plate by the electric current.

3.—REVERBERATORY SLAGS.—The copper, in rich slags, which sometimes contain a little shot copper, is best determined by crushing the samples fine enough to pass a sieve of 20 meshes to the linear inch and then using the fire assay with about one-third more flux than would be required by unmelted mineral of the same percentage of the red metal.

If a complete analysis of the slag is desired, we grind down a small sample to pass a 100 mesh sieve, separating and weighing any shots, and place 1 gram of the fine powder in a 3-inch (7.5 cm.) porcelain casserole.

The slag is decomposed as far as possible by heating with 10 c. c. of strong nitric acid, which is then removed by boiling down with 5 c. c. of sulphuric acid. Add a few drops of nitric acid and 50 c. c. of water, boil and filter. Fuse washed residue with 5 grams Na_2CO_3 and a small fragment of KNO_3, dissolve in water, acidify with hydrochloric acid, evaporate to dryness, take up with dilute acid, filter off, wash, ignite and weigh silica. Purify it by treatment with hydrofluoric acid and add any residue to the main solution. If it is desired to determine the copper in the solution of the first fusion by electrolysis, it may be precipitated with hydrogen sulphide, or the solution evaporated with a slight excess of sulphuric acid.

Another method would be to read the color of the solution of the fusion by the Blue Test. The first solution of the slag contains most of the copper which is determined by electrolysis. Lime and magnesia, iron and alumina, are estimated by usual methods. These slags are sometimes very refractory.

4.—WASTE CUPOLA SLAGS—As a working test, Lake refineries ascertain the amount of the slight loss of copper by the quick Blue Test, the details of which will be found in another paper by the writer, (3) on "Improvements in the Colorimetric Test." Complete analyses are made, as with richer slags, but much more quickly, as the slag is vitrified and easy to dissolve.

I.—ASSAYING OF COPPER ORES OUTSIDE OF THE LAKE DISTRICT.—Most all true ores can be ground to a fine powder from which a very small sample of one gram can be taken and yet represent a large weight of material. Hence, quick wet methods, (the so-called volumetric titrations) are the rule in the far West, where a fire assay would be inapplicable on account of the presence of sulphur. The red metal may be also determined by electrolytic deposition when the ores do not contain much arsenic, antimony, etc.

The wet methods generally used are known as the "cyanide" (4) and (5) "iodide" respectively. According to the writer's experience, the latter is the better of the two. A new promising process has been brought out known as a "modified (6) sulphocyanide," to which reference is also given.

For the determination of gold and silver in copper ores the reader is referred to the text books of Furman or Brown. We have found that, with oxidized ores a large excess of litharge is desirable. On sulphuretted ores, a good mixture of ore and fluxes (which permits a direct assay in the crucible without preliminary roasting) is that known as Aaron's formula, (6b) in which an excess of sulphur and soda is added, and iron nails used to combine with the sulphur and assist in carrying the copper into the slag, an operation that requires considerable time to complete, twenty minutes or more at quiet fusion.

Different methods of assaying for gold and silver are preferred in different localities. (See reference 7 and 8). Mechanical sampling by special machines is the rule, rather than the exception. The value of the lead, zinc and other associated metals is often required as well as the copper—(Western slags are tested for copper volumetrically and by "Blue Test." (See Furman's Manual of Assaying.)

[3] Journal American Chemical Society, January 1897, page 24.

[4] Peter's Modern Copper Smelting edition 1897.

[5] Journal American Chemical Society XVIII, May 1896, pape 458.

[6] Journal American Chemical Society [1898] Vol. XX, page 610.

[6b] Aaron's Assaying Part I.

[7] Trans. A. I. M. E. 1834, page 250.

[8] Engineering and Mining Journal, February 1898, pages 189, 223 and 250.

DIVISION B.—METALIC COPPER.—The following are made at Smelting Works upon the metal from the refining furnaces:—

1. Mechanical tests.
2. Chemical tests.
3. Electrical tests.

1. MECHANICAL TESTS.—At the works of the C. & H. Co., tests bars 2"x2"x12" are cast from each charge of molten copper, as soon as it is judged by small test buttons, to be fully refined. The bar is taken to the machine shop, where a nick, exactly ⅛ inch deep, is made across the bottom at the middle point of the length.

The bar is placed in a specially designed testing machine which supports it at each end, while a plunger is fed down by gearing upon the center of the bar till it parts. A pointer on a dial registers automatically the highest pressure attained, and the pointer is allowed to go back to a fixed point (at about 2-5 of the maximum) before removing the bar. By means of a straight edge and a rule at right angles to it, the amount of bend or deflection of the sample in inches, is obtained.

Other Lake refineries use a Riehle machine, adapted to the same work. If this test of strength went below the limit, the copper would be further refined to maintain uniformly that peculiar strength and toughness of fibre and wearing quality, which make Lake Copper famous for special work, where the metal must undergo severe strains. It is understood that most electrolytic refineries do not apply this mechanical test to their finished metal.

The furnace man tests the steps of the refining process by taking out small samples with a ladle and observing the appearance of the surface while cooling, and the appearance of the fractured surface after nicking and breaking the button.

In the laboratory, the only physical tests made would be an occasional determination of the weight of the metal as compared with water (i. e. its Specific Gravity) and the estimation of the electrical conductivity of any copper which is cast into wire-bar for electrical purposes.

There is another new field of investigation, which has been applied to iron and steel, also to many alloys with interesting and important results. I refer to the examination of the fibrous, or crystalline structure with a powerful microscope, which has often explained physical differences resulting from variations in heating, annealing and other mechanical treatment, which are not revealed by chemical analysis at all. If a small fragment or section of the sample to be tested, is placed on a stick in a bed of wax, or cement, and given a fine polish with rouge, or other abrasives, and then etched with acids, the granular structure of the metal is brought out in bold relief for examination and for the taking of micro-photographs.

Hardly anything has been done with refined copper in the way of microscopic analysis, partly owing to the fact that the metal is so soft, it is almost impossible to polish and etch it in such a way as to avoid destroying its original structure.

NOTES ON THE 'SPECIFIC GRAVITY' OF COPPER.

Practical superintendents and manufacturers frequently object, and in some cases I admit, with reason, that the tests of an invention or of a process in a laboratory, are not to be fully depended upon until thoroughly tried in commercial practice, because laboratory experiments are necessarily conducted on a very small scale. A similar objection may be made with truth to some of the figures obtained for the specific electrical resistance or the specific gravity of copper. Not having access to metal direct from refineries of high grade material, some experiments recorded as standard in text books, have been made with copper melted m the laboratory in small crucibles. De-oxidized copper can be made this way, but copper melted in crucibles can not be given the same physical structure as that refined on the large scale, the metal of commerce.

A few personal determinations are, however, ventured of the specific gravity of native copper, of the refined product direct from the furnaces, and of de-oxidized copper produced in crucibles.

The excellent physical qualities of this last product have been but little recognized. A cast slab of de-oxidized copper, about 2" thick, 6" wide, has been bent double upon itself without tearing and it does not become brittle and crystalline in practical use. It is an ideal metal, when properly prepared, for locomotive stay bolts and for pump rods. It can be rolled down cold.

SPECIFIC GRAVITY OF COPPER.

NAME OF SPECIMEN.	Specific gravity at 60° F.	Sp. gravity of 60 ° F. [15.5 ° C.] referred to water at 4 ° C.
Quincy Native Copper, most solid piece yet found by us [bar planed out 2 in.x2in.x8 in.], pure Native Mass 0.015 per cent silver].....	8.93 [Hard]	8.922
Wire drawn from the same, [annealed].	8.925	8.917
A button of same melted in cup, lined with charcoal	8.950	8.942
A button of same melted, as above, drawn into wire and annealed	8.950	8.942
Pure cathode copper [lake] direct from electrolytic vats—free from silver—[rough sheet drawn into wire and annealed]	a little porous variable 8.89 8.900	8.887
Lake refined, cast, copper from furnaces, [this contains about 0.03 per cent. silver,] bars and ingots	8 67 8.66 8.657 8 67 8.674 8.638 8.648 8.618 av. 8.654	8.646
Cast copper, not wholly poled, [low set, contains more oxygen as sub-oxide of copper]	8.543	8.535
Annealed wire drawn from the cast copper samples....	8.916 8.895 8.898 8.903 av. 8.900	8.892
De-oxidized button produced by melting Lake refined cast copper in a covered cup, made of pure charcoal powder	8.950	8.942

B. .—SAMPLING AND ANALYSIS OF METALLIC COPPER.— A little oxygen in refined copper is not to be reckoned as an impurity, since the poling must be stopped while a trace yet remains, to insure a proper surface set and fibrous structure in the casting.

Generally speaking, the best refined lake, or electrolytic should contain at least 99.90 per cent of pure copper, (including the traces of silver present.) This leaves only 0.1 per cent for oxygen and traces of any other impurities.

It is evident that the exact determination and identification of the traces of foreign metals in the product of copper refineries is a matter of difficulty and requires some of the most delicate manipulations, and exact methods on the part of the chemist of any work with which he has to deal. Especially is this true, because traces, (even 0.002 per cent) of some foreign metals, exert a noticeably injurious influence on the electrical properties of the metal, though not affecting other qualites to any degree (10).

Dr. H. F. Keller, stated in a short paper, in 1894, "That the exact manner in which these impurities affect the physical properties of copper is not better understood, is undoubtedly owing to the lack of rapid, and at the same time accurate, methods of ascertaining their relative amounts." This is not so much the case to-day, since papers by several authors have given not only the details of the standard methods, but also several new methods for accurate work.

As in this country, the technical analysis of refined copper is confined to comparatively few hands, a few details will be given, in this paper, of such improvements as have proved to be of advantage, up to date.

[10] Journal American Chemical Society, Vol. XVI [Nov. 1894] page 784.

SAMPLING OF COPPER (AND MATTE.)—Matte can be crushed so its sampling is not so difficult as that of copper pigs, bars or ingots, which are chipped or drilled. A fixed proportion of pigs, bars, or ingots are taken from a lot or invoice, and holes bored part way through, but in a different place on each one, following a regular rule, in order to avoid or correct for, the effect of unequal segregation of the impurities in the copper (notably gold and silver) on cooling from the molten state after casting.

The interior of any thick casting of copper, (similarly to iron and steel) retains more of some impurities (and less of others) than the outside half which solidifies first.

(11) Edward Keller, of the Baltimore Works, concluded as the result of the most careful investigation of this subject ever published, that to sample gold and silver-bearing copper correctly and avoid segregation, the sample should not be taken from large bars, or pigs, but cast direct from the thoroughly mixed molten charge in the furnace, in the form of a thin flat plate, which will solidify quickly and evenly throughout, except for a distance from the outside edges, not over twice the thickness of the plate.

Very small buttons taken direct from the furnace give a good sample also and these methods are followed by Lake smelters in sampling copper, the size of test plate being 6"x6"x½" for silver assay.

If a box or ingot must be sampled, the surface rust is removed, and a dry drill, or plainer, employed to take borings, or sections, from the test piece, testing the piece afterwards with a magnet.

ASSAY FOR SILVER AND GOLD—The standard methods are fully discussed in a symposium of assayer's prepared by the Secretary of the American Institute of Mining Engineers after the plans of Dr. Ledoux of New York. A more recent account of assays at the mint is published by Whitehead and Ulke. (See references 7 and 8.

The so-called "combination," or wet and dry assay of gold and silver in copper has generally given rather lower results on gold than an "all-fire" assay, owing to the slight solubility of the precious metal in the acid used to dissolve and separate the copper.

(12) Recently, L. D. Godshall claims to obtain the rest of the gold by throwing out a very little copper from solution with hydrogen sulphide, carrying down the gold also.

[11] Trans. A. I. M. E. 1897, Vol. XXVII, page 106.

[12] Trans. A. I. M. E., Feb., 1900; also Eng. and M. Journal, Feb. 24, 1900, page 228; April 21, 1900, page 470.

THE ESTIMATION OF PURE METALLIC COPPER IN COMMERCIAL COPPER.—In matte, the precentage of copper is determined generally by volumetric processes already referred to or by electrolytic assay.

When we come to metallic copper, so close to 100% pure, the electrolytic assay must be employed.

The pure rose-red copper is deposited from an acid solution upon a platinum plate.

For a full description of the necessary precautions, refer to another paper (13) on the Electrolytic Assay as applied to refined copper.

OXYGEN IN METALLIC COPPER.—Some chemists have attempted to ascertain the amount of the traces of oxygen (existing as sub-oxide of copper) in refined metal by treating with a solution of nitrate of silver.

This is a rather uncertain reaction. The scientifically exact method is that devised by the German chemist, Hampe. (14)

One or two American chemists have improved the original and rendered it more rapid and easy of execution.

The writer cleans the copper quickly with pure petroleum ether (completely volatile below 60° C) instead of by Hampe's treatment with caustic potash, and absorbs any evolved sulphur by alkaline cadmium solution.

The principle of the method is the determination of the loss of weight suffered by a sample of clean fillings of the copper when heated in contact with a current of perfectly pure hydrogen gas. This loss of weight is called oxygen, but must be corrected also for any slight trace of sulphur or arsenic which may be driven out with the oxygen on heating the copper.

THE SULPHUR IN COPPER.—The complete removal of this harmful element depends on the care with which the final refining in the reverberatory furnace is conducted. Much lake copper contains hardly a trace.

Hot copper absorbs both oxygen and sulphurous gases with great rapidity so that trouble sometimes results in rolling mills in re-heating the metal, from too high heat in contact with the flame of crude oil used as fuel.

The only rapid and exact chemical method, known to the writer, for the estimation of even minute traces of sulphur in metallic copper, is one published by him in 1895, (15) which depends on the removal of the copper from its nitric acid solution by electrolytic deposition on a platinum plate, leaving the sulphur compounds in the liquid. This solution is evaporated to dryness with a little soda as described in the Journal referred to, and the sulphur exactly estimated.

[13] Trans. A. I. M. E., July, 1897.

[14] Fresenius Quant. Analysis, Book II, page 519.
Post Ch. Tech. Analyze, Vol. III, page 526, (German.)
Zeit. Fur. Anal. Chemistry, Vol. XIII, page 202.

[15] (a) Journal American Chem. Society Vol. XVII., Oct. 1895, page 814.
(b) Abstract in Eng. and Min. Journal Feb. 29, 1896, page 204.

FOREIGN METALS IN COPPER.—Dr. H. F. Kellar gave a good outline of Hampe's directions for the complete separation and analyses of foreign metals and metalloids in refined copper as practiced by him at that time.

Very little has been translated from the German except the above account, and a direct abstract of the original method in the Journal of the English Society of Chemical Industry. (16) See also, Fresenius' Quantative Analysis Book II, (complete edition).

For a thorough analysis, we make use of modifications of the above mentioned process, taking one 50 gram sample for the determination of gold, silver, selenium, tellurium, arsenic, antimony, and tin, by the "sulpho-cyanate method," and sometimes a second sample of 25 to 50 grams for the separation of lead, bismuth, iron, zinc, cobalt and nickel by the "electrolytic method:" Estimations of single constituents can be performed more quickly by some special process.

What copper and its analysis was before the development of modern metallurgy is illustrated by some analyses found in Foster (17) and Whitney's Geological Report of the Lake district for 1850.

After stating that "the native copper from Lake Superior mines may be considered to be chemically pure," they quote the following analyses of Europeon refined coppers of the day, which were copied as a matter of curiosity: No. 1. Swedish copper. 2. Mansfield (analyzed by V. Kobell). 3. Swiss copper.

Analyzed by Berthier.	I	II	III
	Per cent.	Per cent.	Per cent.
Copper	98.655	98.251	
Iron	.055	.131	.17
Nickel	——	.236	
Lead	.751	1.092	
Silver	.226	.135	
Potassium	.116	——	.38
Calcium	.095	.107	.33
Magnesium	.033	.048	
Aluminum	.021		
Silicium	.048		
	100.00	100 00	

[16] Journal Soc. of Chem. Industry [London] April 30, 1894, page 421

[17] Ex. Doc. 69, U. S. House of Representatives, 1850, page 177.

I have not yet discussed the important test of the electrical resistance, (or conversely the electrical conductivity) of the metal, as compared with the standard values established by the European investigator, Matthiesen, for the purest copper known in his day. This standard is still adhered to by the scientific world for convenience, though refined copper (from some sources) will test, in the form of annealed wire, over 100 per cent pure.

The conductivity test is now the criterion of the metal to the manufacturer, the large rolling mills, and even the brass foundry.

What is really measured, is the resistance offered, by a piece of hard-drawn, or annealed wire to an electrical current. The length of the test piece (to 1-10 millimeter) the weight (or average diameter) and the exact temperature of the instrument (and wire) are recorded at the time of the observation of electrical resistance.

Although rolling mills make their working tests on hard-drawn wire, the true comparison of coppers can only be made on the annealed wire, which gives the maximum conductivity of which a copper of given percentage of impurities is capable, while the hard-drawn tests 2.5 to 3.0 percent lower. The exact difference, evidently, will vary with the mechanical treatment given in each mill.

Formulas for calculation which depend on the weight of the wire, rather than its average diameter (and cross-section), are much more accurate, as wires are hardly ever perfectly round, and when pear-shaped, the exact determination of the average diameter is almost impossible even with spring calipers, which apply steady pressure.

The works with which the writer is connected, possess a small but complete model mill outfit for rolling and drawing test-bars (7"x½"x½") which are cast from the molten furnace charge as soon as it is thoroughly refined.

If the copper does not give a test above a fixed limit, it should be re-melted.

Manager Klepetko reported (in the Trans: A. I. M. E. for 1897, page 967), that similar tests were made by the Boston and Montana on their refined metal, as is also done at other smelters.

METHODS OF MEASUREMENT OF RESISTANCE.—Many years ago the resistance of copper wire (and its relative conductivity therefrom) was tested on the original forms of Wheatstone's bridge system, involving large extra resistances in boxess plugs, and lead wires which must be allowed for.

Twenty-five to fifty feet of the wire had to be carefully straightened, measured as to length (and diameter if not weighed) and its temperature taken aside from that of the bridge coils—an operation so slow as to leave much to be desired for practical use.

Owing to the great growth of the industries handling copper, and the higher grade of specifications for the metal, there grew up a demand for a standard conductivity bridge, specially adapted to wire testing, that should fulfill the following conditions. As the result of long experience the writer believes the following to be requisites for a test which is adapted to commercial work, and yet accurate:

1st. Extra and variable factors, such as all resistances of plugs, contacts and connecting wires, must be neutralized, or eliminated, so as to have no effect upon the observed resistance (or fall in potential) in the sample under test, at ordinary working temperature.

2nd. The method must be rapid enough for commercial use and yet accurate; the instrument not likely to get out of order, and most carefully checked against the Cavendish standards of England.

A set of copper wires, whose resistance has been carefully determined against recognized standards should be provided by the maker of the Bridge, so that it may be checked from time to time and any alteration detected.

3rd. The test should be made on samples of wire not over one meter in length, so they may be laid out straight upon the instrument. The preparation of long samples (seven to ten meters) is too slow, and the temperature of the coil is necessarily different from the bridge.

If a very accurate test is occasionally required, and short pieces are being tested, let several samples be tried, and the results averaged.

It is a great advantage that short pieces (of less than one meter) may be placed upon the instrument, and in ten minutes or more will acquire its exact temperature. At least ten minutes is required after handling (and thereby heating) the wire with the bare hands. This is a point in manipulation that is sometimes, to my knowledge, rather overlooked and neglected by electricians doing this work.

Even a foot or two in distance from the observer's body (or in height on table or shelf) will oftentimes make a difference of two or three degrees Fahrenheit, and it is remembered that every degree means a difference, either up or down, of over 0.2 per cent in conductivity.

INSTRUMENTAL METHODS FILLING SPECIFICATIONS.—One is the design of Prof. Puffer, I think, in use at the Massachusetts Institute of Technology, Boston.

Observed results are independent of the existence of contacts and connectors, but a 20-foot sample is tested, so it is rather too slow for rolling mills, and out of the question for most copper refineries.

The sample to be tested is stretched in a long box, beside two or three copper wires of known resistance, and by means of a traveling weighted knife edge contact, carried on a little wheeled truck, the length of the test sample is found (on scale behind or below it) which has exactly the same electrical resistance as the total length of the standard.

The next two pieces of apparatus described are more adapted to mills and smelters.

The first is the bridge by Siemen's Bros., London, which is a modified form of Thomson's double bridge, and is possessed by the Calumet and Hecla refineries. It is used considerably in Europe. It is designed to give measurements of low resistance entirely independent of the resistance of the pinctions between the wire to be measured and the knife edge contacts. About 600 mm. of copper wire are cut off for a test.

By allowing time for all samples to acquire exact temperature of bridge, using accurate thermometer reading to 0.2 degree F., measuring length within 1-5 mm., and reading resistance scale with a hand-glass to 1-10 of marked divisions, check observations may be made within one-tenth per cent. of each other.

A possible objection to this instrument is that one has to depend on the care with which the maker has tested the standard wire, of alloy, for every part of its entire length.

An instrument in more general use in America is the Standard Conductivity Bridge, made by Willyoung, Philadelphia, U. S. A.

Rolling mills have installed this apparatus until the following American concerns, among others, possess them: Roebling Sons Co., Waclark Wire Co., Coe Brass Co., Bridgeport Brass Co., Michigan College of Mines, Pittsburg Reduction Co., Boston and Montana Copper Co., Seymour Manufacturing Co., Lake Superior Smelting Co., etc.

This test depends on the Carey-Foster method, the use of which eliminates errors due to contacts, etc., and measurements on samples of copper do not have to be corrected for temperature, since the standard wires in the machine are also of copper, and at the same temperature as the test, if enough time is allowed.

In spite of these comparatively accurate instruments (among other designs to the same purpose, which are already in the field), there is room for improvement somewhere, as different instruments, even from same makers, when checked against the same samples of wire, do not always agree quite as closely as they should, or as they are claimed to do.

In conclusion, I trust that I have succeeded in explaining, by the foregoing outlines, the many means now employed in examination of the output, and the control of the losses, in a modern smelting works; and in indicating the fact that scientific investigation has been the "eye-opener" which (as in other industries) has replaced the old "rule-of-thumb" methods, by an intelligent knowledge of the reactions involved in the smelting of the new "king of metals."

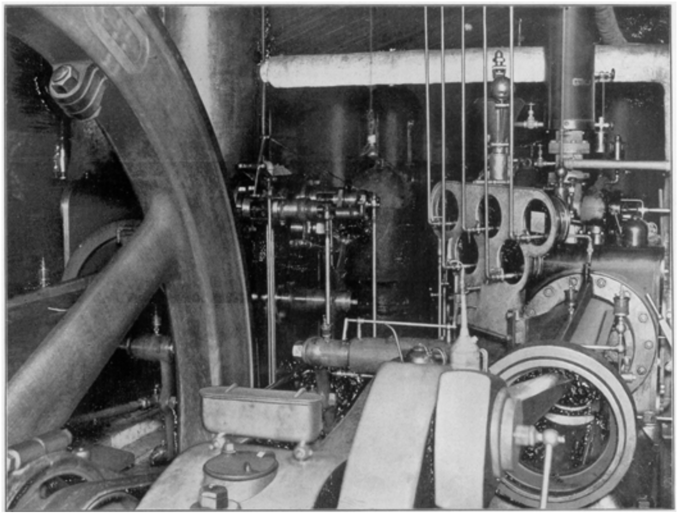
MR. HEATH'S PAPER OPEN FOR DISCUSSION.

DR. KOENIG: I wish to ask Mr. Heath a question, only in regard to his reference to the fire assay, he says it has been somewhat ill-spoken of elsewhere. I will give my own testimony that it is a very good assay, perfectly reliable.

MR, HEATH: I will say I think that it is mentioned in an original account by Mr. Patch, a copper smelter, that it has been objected to outside of Lake Superior as an inaccurate process, because they do not regard the fact that our copper does not produce any sulphur. I think we can rob the slag of nearly all the copper because the metal contains no sulphur.

MR. COOPER: I think one objection which is often raised to the Lake Superior fire assay by a number of persons who have tried to make their assay by taking their sample from the dried mineral. I do not think that will do unless the mineral is composed of particles absolutely of the same size, which we know is not possible in minerals of this district. In taking the assay sample from the dried mineral, the coarser, heavier grains of copper are more easily retained on the spatula. Thus a larger portion of the smaller grains of copper and the gangue drop off, thus leaving the sample too high in copper.

I have in mind an example. A dried sample of mineral passed to and fro between two chemists. Each time the dried sample was assayed, the percentage of copper found was lower than the previous assay showed. Therefore, to get a correct sample, it is necessary to moisten the sample enough to make the particles adhere.



PUMPING ENGINE IN PENOBSCOT MINE

CORLISS CROSS-COMPOUND PUMPING ENGINES IN PENOBSCOT MINE.

BY JOHN A. REDFERN.

When sinking our shaft in 1896, we encountered some difficulty with water, but not more than our neighbors, so that when the time came for the installation of station pumps, we had no reason to expect a greater flow of water than other mines in our vicinity were getting at a like depth.

Early in 1897 we therefore put in a tandem duplex, compound condensing, Prescott pump, of 800 gallons normal capacity and another Prescott simple pump of the same capacity, for a relief in case of an emergency. As we began to open new ground, however, we were surprised to find the water increased with almost every foot opened and in such volume that we were compelled to order new pumps with such rapidity that within a few months we had 5 of these compounds, and a simple; in all a normal capacity of about 4,000 gallons per minute. We then ran along pumping a quantity varying from 3,500 to 4,000 gallons per minute, without any marked decrease. In fact it was impossible to open ground as fast as desired for fear the inflow of water would exceed our pumping capacity.

Last year it became evident that our pumping was going to be a continuous problem, and the quicker we put in a central plant, sufficiently large and of a type to do the work at a minimum cost, the better. We therefore began investigations as to the relative efficiency of the different classes of pumps, their comparative costs and the probable saving in fuel that could be effected over our present method of handling water. The first step in this direction was the necessity of getting definite knowledge as to the economical performance of our direct acting compound pumps, without regard to the efficiency of our boiler plant, or steam that was being used elsewhere.

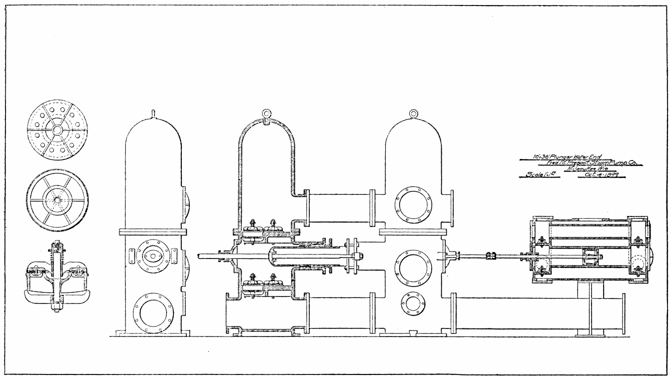
From tests then made, it was found that our compounds were giving us, not to exceed, a duty of forty-four million, and that we were evaporating 8½ pounds of water from and at 212° per pound of coal. At the existing price of coal and with this evaporation the cost of handling such a large volume of water was too high. We investigated in turn the Cornish, triple expansion, direct acting, and crank and fly wheel types of pumps, in an effort to determine which would give the greatest returns consistent with their installed cost. The Cornish system was quickly abandoned because of its tremendously excessive first cost, its inadaptability to varying conditions and generally obsolete character, so that it resolved itself into a choice between the triple expansion, direct acting, and the crank and fly wheel form. Both of these were recommended, the first because of its lower original cost and general simplicity of construction, while its economy approached the crank and fly wheel type so closely that some doubt remained as to whether this would not make up for the increased cost and higher efficiency of the latter.

In making estimates of the probable fuel cost of the two types we took the duty of the triple expansion at 80 million and the crank and fly wheel at no million, both of which assumptions were corroborated and guaranteed by the manufacturers.

The volume being so great and the chances that the conditions would remain unchanged, it was concluded to install the higher priced and higher type pumping engines, which guaranteed a saving, to be conservative, of at least 50% of fuel cost, in operation.

On arriving at this dicision, a contract was placed with the Fred. M. Prescott Steam Pump Co., of Milwaukee, Wis., for two corliss cross-compound condensing pumping engines, each having a normal capacity to deliver 2,500 gallons per minute, against a static head of 290 feet, at a steam pressure of 125 pounds, at the engines. These pumps were installed last fall and both are now in continuous and successful operation. The engines are cross-connected compounds with 19” h. p. steam cylinders and 35” 1. p. steam cylinders.

Both the high pressure and the low pressure cylinders and their respective heads are steam jacketed, and in addition the bodies of the cylinders are covered with non-conducting matenal and then lagged with planished steel. The engines are provided with receivers of the “re-heater” type and every precaution is taken to guard against losses due to condensation or external influences. The valve gear is of the Corliss type, automatically controlling the point of cut-off and with regulators having special attachments so that the speed of the engines can be adjusted to suit the varying conditions of speed required. The pumps are placed tandem to the respective steam cylinders, the piston rods extending through the back of cylinder heads and connecting direct to the pump plungers. Engines and pumps being rigidly tied together by means of steel stretcher rods. The water ends are Cylindrical in form and have a large air chamber over each quarter of the pump.



PUMP IN PENOBSCOT MINE.

On the inboard end of the pump are two suction chambers, cross-connected, but with a gate valve between. In each discharge before entering the header, is placed a special check valve.

With this arrangement, by closing the gate in the cross suction and the required check valve in the discharge, we are able to cut out either side of the pump and run one half of it. This is an emergency precaution and a valuable one. The water valves are peculiar in that there are only three suction and a like number of discharge valves in each quarter. They are of the annular ring type which permits enormous openings without the high lift common to valves of ordinary construction. High plunger speed being desirable on account of resulting economy of the steam end, all the valve and water passage areas were made extremely large and are something over 200% of the plunger area. So that when these pumps are running at normal speed, 306 feet per minute, the velocity of water traveling through the valve openings is less than 150 feet per minute, or less than in ordinary pumps when running at their customary plunger speed of 100 feet. The plungers are 10" in diameter and all of 36" length of stroke. The condensers are of the jet type mechanically connected to the main pump on the low pressure side. There is an attached auxiliary pump for boiler feed purposes, having no nearer supply of feed water. This small pump receives its supply direct from the condenser and discharges through a heater located in the engine exhaust, between the low pressure cylinder and the condenser. By this method we are enabled to utilize the heat in the water for our boiler feed.

On the 20th of last December a duty test of 10 hours duration was made, the results being as follows:

Number of steam cylinders..............		4
Diameter of high pressure cylinders....		19″
Diameter of low pressure cylinders......		35″
Number of water plungers (double-act'g)		4
Diameter of water plungers.............		10″
Diameter of plunger rods—front end....		$2\frac{1}{2}$″
Diameter of plunger rods—back end....		$1\frac{3}{4}$″
Stroke of plungers and steam pistons....		36″
Net area of plungers (avg. for both ends)		74.88 sq. inches
Total feed water weighed in barrel.....	58,850 lbs.	
Drips and overflow weighed back.......	376	
Total water fed to boilers...............		58,474 pounds
Moisture in steam 2.12%.................	1,239 lbs,	
Water discharged by separators.........	1,728	2,967
Total dry steam charged to engines.....		55,507 pounds
Duration of trial.........................		10 hours
Average dry steam used per hour........		5,550 pounds
Average steam pressure at throttles by gauge		125.7 "
Average vacuum.....		26.3 inches
Pressure by gauge on discharge pipe....		112 pounds
Average distance from center of gauge to level of water in sump..............		14.1 feet
Equivalent in pounds per square inch....		6
Total head pumped against..............		118 pounds
Average revolutions per minute.........		51
Average plunger travel..................		306 ft. per min.
Water pumped during trial per minute..		4,761 gallons
Duty per 1,000 pounds dry steam 74.88x-306x118x60x4x1000—5,500...		117 mill ft. lbs.
Contract requirement—duty per 1000 lbs. dry steam.............................		110 " " "
Excess over contract requirement..... .		7 " " "

It will be seen from this that the results exceed our most sanguine expectations and that of the builders. The guaranteed duty was 110 million per 1,000 pounds dry steam, without making any allowance for leakage between boilers and engines, this was exceeded by 7 million.

Inasmuch, however, as this high point of efficiency was reached when everything was finely adjusted and the plant very skillfully handled, it is not expected to equal it under continuous operation, but if we can maintain the 110 million mark the fuel cost should not be more than one half of what it was with the old compounds, which is very gratifying and well worth the expenditure. While the rated capacity of each of these two pumps is 2,500 gallons per minute, a speed test was made in order to ascertain what could be done in case of emergency. On this test we ran quietly 79 revolutions per minute, a plunger speed of 474 feet, or a delivery of 3,860 gallons per minute for each pump, or a total of 7,720. I do not know how much faster we could have run, but thought the test satisfactory and slowed down again. So far as I know this is the highest plunger speed at which an underground pump of this capacity has ever been successfully and quietly run, and the economical results as measured in foot pounds of work for a given quantity of steam, I believe is the highest ever reached by any underground plant. To operate these pumps we installed a battery of 3-250 H. P. Wickes, vertical, water tube boilers, one of which will operate both pumps at their maximum capacity. The pumps are connected to the boilers by a 6" steam line covered with 1½" of 85% magnesia covering.

THE INVASION OF THE WATER TUBE BOILER INTO THE COPPER COUNTRY.

BY O. P. HOOD.

The firebox type has been so universally used as to be characteristic of the boiler practice of this locality. While the rest of the country was using brick-set, return, tubular boilers the copper country had relatively few examples of that type. In but one large mine did they become the standard. The features of semi-portability, absence of brick work and rapid steaming, together with low price, made the firebox type a favorite for mining operations from the prospect shaft to the permanent equipment stage. The Belpaire form of this type used by one company was also designed for high evaporative performance.

The boilers have had a gradual evolution within the copper country. The crown sheet was replaced by crown tubes for greater safety and ease of repair. The length has undergone several changes. Arch tubes have been introduced running from the back water leg above the fire surface to the front water leg just below the crown tubes. This improves circulation, and by bricking a baffle plate up the arch tubes a few feet, it is expected to better the furnace conditions. The boiler design has developed to meet the increasing pressures up to 150 pounds and increased size of units up to 84 inches in diameter of shell are made.

The many new boiler plants in the district have attracted all the new claimants for favor in the boiler field and the conditions attending the introduction of new types is of interest.

The agent representing a new boiler here, finds the field occupied with a type with which he has but little familiarity. I believe no other section of the country employs the firebox type so exclusively. This fact is used as an argument for a change. In trying to discover the influences used in bringing a change in boiler practice, I find the fear of being called "old foggy" and "not up to modern practice," having more weight than it should. It must not be lost sight of that this remark is usually made by those having a special interest in some other type.

Beside this assumption can be put that other assumption that a boiler developed under local conditions is likely to fit those conditions and that the new type must yet prove itself. Among many advantages the agent of a new type claims a much higher evaporation per pound of coal. It is a little surprising to find that the old type has possessed no figures with which to make a comparison. In order to show that the old type can be bettered in this particular it is certainly necessary to have something more definite than general impressions as to what that type has been doing.

Several tests of each type recently made in this vicinity do not uphold the claims of the new type for superiority in this particular. It is not proven that the local type is evaporating less per pound of coal than the new types installed. Tests of the firebox type so far made show in each case an evaporation per pound of coal of over 10 pounds of water from and at 212 degrees. The proposition as to relative evaporation is an assumption as yet and should not be given undue weight.

It is claimed that the flue temperature in the local type is higher than it should be. Figures from plants in good order show no great difference as yet in this respect. Flue temperatures of 427, 477, 544, found with the firebox type are quite comparable with temperatures found with water tube boilers. The steam quality as shown by the calorimeter appears equally good in each type also. Since both types are very easily forced and run much above their normal rating it is a common thing to find, particularly the older boilers, very much overloaded giving high rates of combustion, high flue temperatures and wet steam. This is done in many cases where it is not realized how much the boiler is being overloaded and gives rise to the belief in abnormal flue wastes and wet steam. In point of safety the water tube type enjoys distinct advantages at very high pressures. It is a significant fact, however, that with pressures heretofore carried this locality does not record a single boiler explosion of the crown tube type with all of its flat, stay-bolted surfaces and frequent overloading.

The new types of boilers are represented by gentlemen who are above all things expert salesmen. The old type enjoys none of that delightful commercial exploitation which makes it a pleasure to buy something one knows very little about and really does not want.

The first water tube boiler in the district was installed at the College of mines in 1894. A small Stirling boiler there was followed by plants at eight other points. I have visited most of these and find among those in immediate control some preferring the new type, others the old. Three plants have figures with which to illustrate their opinion. In thus comparing the two types the points so far mentioned may appear to be unfavorable to the water tube type of boiler. I wish to emphasize the fact that this appearance is defective. There are great advantages of the water tube type not mentioned. If the proportion was reversed and it was asserted that the firebox type of boiler along the lines mentioned was always superior to the performance of the other type I should be obliged to take a conservative view opposing this. I wish to discover and to champion the facts in the case and not a particular type of boiler. So far I do not find an evident superiority along the lines of evaporation, flue temperature and steam quality as has been claimed. The attitude which appears to me the fairest in this case is illustrated by one manager who said: "The new type impressed me favorably and I was willing to pay the difference to try the experiment.

The points which I wish to make in this paper are: First, that the many excellent boilers being presented for adoption into the copper country are not necessarily better than the type developed in the locality; second, that in so far as miscellaneous tests can show anything, superiority of the new type along the line of economic evaporation, steam quality and flue temperature has not yet been shown here; third, that in weighing the merits of the firebox type as used here, there is a serious lack of figures from tests as definite as those presented by the newer types from other localities.

As new boilers of either type are put in it is hoped that careful tests will be made to discover whether a reasonable guarantee is fulfilled and thus supplement our present knowledge.

MR. HOOD'S PAPER OPEN FOR DISCUSSION.

DR. LANE: I would like to ask if the Wicks water tube boiler has been tested.

MR. HOOD: In answer to that I would say I find no figures at all. They have been here but a short time, and I understand no tests have been made as yet.

MR. DENTON: I think there are a good many here tonight who have some opinions to express with regard to boilers, and in order to bring out remarks from some of these gentlemen, who would like to state the other side of the question in one or two directions. I think Professor Hood's remarks in regard to local developments being usually best suited to each locality, are good. On the other hand, as one travels around the manufacturing centers of the country, I do not think that one new installation of the boilers of the locomotive type will be found for perhaps ten of the other type. Of course these figures are simply guess work. However, there are certainly more new permanent boiler plants of the water-tube type being installed than of the locomotive type, if one considers a large area, and I offer this fact as an argument, to offset the one drawn from the local tendency, at least in the past, towards the locomotive type.

As Professor Hood says, there is probably not much difference in evaporative powers when both types are under normal conditions. The fact of the greater safety of the water-tube type, which Professor Hood has also referred to, is alone sufficient in my opinion to give this type the preference in any permanent plant upon which a great deal is dependent.

Furthermore, I think that by ordinary repairs and renewals of parts of water-tube boilers, the pressure may be maintained continuously at that for which the plant was designed. The maintenance of the steam pressure which is gradually becoming higher is at most plants a more important item then formerly.

With locomotive boilers the custom has been, as the plants grow old, to reduce the pressure as there are usually uncertainties in regard to the condition of the shell. Assuming a high steam pressure to be continuously maintained, I think the cost question will also favor the water-tube boiler. It is assumed of course that the feed water is good.

PROF. HOOD: In figuring on a plant to-day, the question of fuel is looked upon as the most important thing, and as plants are apt to be concentrated, they generally run up pretty high in horse power. Probably four or five or six boilers. Of course the safety becomes of the first importance, and I think is given a great deal of weight. Next, in regard to operation, From all the figures I have been told about, I should judge there wasn't much difference as far as the fuel question goes, but there was as to the safety of the boiler and one of great importance. Secondly, I think that in the long run the water tube type of boiler can be kept up to the originally designed pressure as with the fire-box type.

MR. MCKEE: I would like to inquire whether there was an effort made to introduce the mechanical stoker on these boilers.

MR. HOOD: There has been put in one mechanical stoker in the Wolverine under two Sterling boilers, each of 200 horse power. That is the only one to my knowledge.

MR. MCKEE: Has there been any under the fire-box?

MR. HOOD: None to my knowledge.

MR. POPE: There are mechanical stokers in the Quincy mill.

MR. THOMPSON: I would like to suggest that there are water tube boilers and water tube boilers and the variation between them may be as much as the variation between the water tube type and the fire-box boiler and the horizontal tubular boiler.

MR. HOOD: I have a test by a noted expert which shows a difference of fourteen per cent in effeciency in two boilers of apparently the same design, and it is difficult to class a boiler of a single design against another boiler which admits very many different designs. Personally I am in favor of the water tube boiler. At the same time there has been in some cases a very heavy bill of costs for repairs, and that is a question which perhaps should be considered quite as much as the fuel question.

DR. HUBBARD: The argument is brought forward in favor of the water tube boiler or rather against the tubular boiler, and in the course of ten or fifteen or maybe twenty years the boiler is so far gone that although it still may be good for low pressures, the insurance people will not allow it to be used at as high a pressure as it was originally designed for, and hence it has to be thrown out or used at a loss of economy. The tubular boiler can be installed for $8.00 or $10.00 per horse power, several dollars less than the cost of the water tube type. By making it 1-16 or ⅛ of an inch thicker, why couldn't the manager of a plant that required a pressure of 125 pounds, buy a boiler that could stand a pressure of, say, 160 pounds. That boiler would surely last indifinitely without having the insurance men cut down the pressure below the required limit. I make this suggestion in order to ask if there is any different rate at which the boiler insurance people do cut down the pressure. When we can install a boiler for $8.00 a horse power, we can figure, even if we may have to throw it out at the end of twenty years, a saving in that time over the cost of a water tube boiler at $13.00 per horse power, that will be sufficient to replace the former.

MR. JACKSON: I rise for the purpose of stating that I do not know anything about boilers, but would like to commend the attitude of Professor Hood's decision in this matter, I think that a very much more important matter than the mere efficiency of the boiler is to be considered. The amount of water it evaporates to the pound of coal is the matter alluded to by Dr. Hubbard. It is a fact that some people allow it to scale, and those things will knock out a boiler very quickly. The main consideration strikes me that the people who are going to look after these boilers, should see that they be kept in good working condition. That is a very important point. After a boiler is once installed, it is not in every place it gets the best possible attention, and I should select one which would be most likely to be kept in order without too much trouble.

MR. HOOD: I fear that it may be taken that this is a plea for the firebox boiler. It is not. Perhaps I can present as many facts on the other side. What I tried to point out is this: That among a good many conditions there are two or three I propose to consider. With the new type of boiler (and I use that term instead of saying Stirling boiler) we expected and had a right to expect from the claims of the agents, that a very noticeable increase in steam could be had per pound of coal. We couldn't say "no," for the reason that there were no figures available from the firebox type. And when it was claimed that the Stirling would evaporate 11 or 12 or 12½ per pound of coal, we could not say that the firebox was doing as well, for I don't think we knew. In making tests, those that have been made so far, show that neither are evaporating 11 or 12. If we take the figures so far, the Stirling shows less than the firebox type. Going no further than the evidence I say that the claim has not been substantiated. As far as I studied the subject, I find that if you look for 11½ per pound of coal, you can find it with any type of boiler.

MR. MCKEE: My company has very few boilers less than twenty years old all built for from 80 to 90 pounds and insurance people still take them as high as that, with one or two exceptions. These are boilers that were made in the days when iron was all there was to be had and it wasn't good at that. We have some steel boilers that have been in service almost twenty-one years, a battery of six. Five of these boilers are taken today at 80 pounds, and the other one would have been so taken if it wasn't burned by firemen and improperly patched. I think you can say that a tubular boiler will run twenty years, and perhaps with good care, thirty years, and in my opinion with pressures usually carried for mining work will give as good or better economy than water tube boilers.

A NEW FORM OF MINE DRILL BIT.

BY WALTER FITCH.

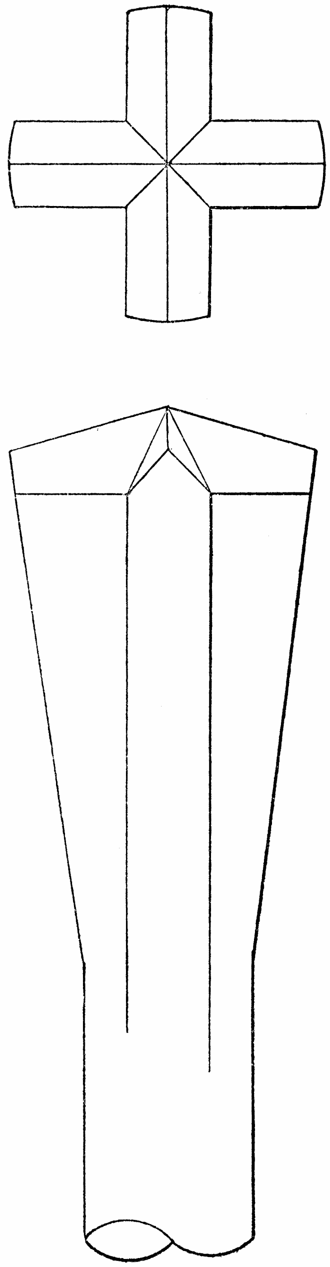
In response to a request of the President of the Institute that I should prepare a paper for this meeting I acquiesced, with an idea of presenting some tests that I had made some years since, of two forms of rock drill bits; one of which was new, and was invented by Richard Simmons, the head blacksmith at the Champion mine, and the other was the old form of cross-bit. In order that these tests might be confirmed under present conditions of higher air pressure and larger drilling machines we have recently made additional tests with different machines, these being of three sizes, viz: Two and seven-eighths inches, three and one-fourth inches, and three and one-half inches diameter of cylinders.

The results of these tests have shown that with increase of power there is an increase of efficiency in the ordinary form of cross-bit, but that with the machines now in use in the mines the Simmons bit is very much more efficient.

In treating of the subject I sent to the patent office at Washington for diagrams of rock drill bits that had been granted patents, and received over thirty different descriptions, none of which I had before seen illustrated or in use. None of these appeared to present any marked features that would commend them for use in our mines. Some of them were designed, undoubtedly, to overcome difficulties that occur to all of us, but these would have to be rejected because of the labor and expense of preparation and repairing. It is singular, that of the numerous forms that have been patented, none, to my knowledge, are in general use. I was informed that those sent me represented only a small part of the number remaining in the patent office.

The cross-bit it will not be necessary for me to describe, as I believe it is used practically in all of the mines of the Lake Superior district.

The bit used in competition with this, which I mentioned in my introduction as being novel, is described as possessing for its cutting surface the single bit common to the ordinary hand drill, with the addition of two shoulders or reamers set at right angles to, and back from the cutting edge five-eighths of an inch and approximately five-eighths of an inch wide, and having the same radius as the cutting bit.



CROSS BIT.

The first competitive test proved that two of the radiating cutting edges of the old cross-bit acted to retard the progress of the drill, and much greater speed could be gained by dispensing with them. The reamers were added in order to maintain as far as possible the gauge, and to preserve the cylindrical form in drilling the hole.

It was argued that adding to the cutting edge of the drill, without adding to the power behind it, could not increase its cutting ability.

This contention, I believe, has been demonstrated by subsequent tests, for these prove that with increased air pressure and more powerful drilling machines, the advantage of the new drilling bit was less marked, and the cross-bit more nearly approached it in speed. One other feature apparent with the faster boring with the increased power, was that the loss of gauge was not as great, resulting from the lessened number of strokes required to do the same work as formerly.

The test made several years ago with a 2⅞" Rand drill with sixty pounds air pressure as recorded at the air compressor was as follows:

TEST NO. 1.

In this test the holes drilled were in jaspar, the hardest ground found at the time at the Champion Mine.

CROSS-BIT.

Drill	Gauge Starting	Gauge Finish	Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per Min.
1	2-11-32	2-3-16	5-32	38	13-1/4	
2	2-7-32	2-3-32	1/8	67	6-3/8	
3	2-1-32	1-31-32	1-16	31	9	
4	1-15-16	1-7/8	1-16	56	12-1/4	
5	1-7/8	1-13-16	1-16	26	13-1/8	
6	1-13-16	1-3/4	1-16	19	14	
7	1-11-16	1-29-64	15-64	52	13	
			49-64	289	81	.280

SIMMONS BIT

Drill	Gauge Starting	Gauge Finish	Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per Min.
1	2-3/8	2-19-64	5-64	20-1/2	12-1/2	
2	2-19-64	2-1/4	3-64	8-1/2	7-1/4	
3	2-1/8	2-1-16	1-16	30-1/2	19-5/8	
4	1-7/8	1-13-16	1-16	29	22-1/8	
5	1-43-64	1-19-32	5-64	34	19-1/4	
			21-64	122-1/2	80-3/4	.659

TEST NO. 2.

In this test the holes drilled were in a mixture of Chloritic Schist and Magnetite, this being the easiest drilling ground known at this time at the mine:

CROSS-BIT.

Drill	Gauge Starting	Gauge Finish	Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per. Min.
1	2-3/8	2-11-32	1-32	14	23-1/2	
2	2-1/8	2	1/8	23	25-1/4	
3	1-27-32	1-27-32		12	17-1/4	
4	1-23-32	1-22-32	1-32	8	16	
			3-16	57	82	1.44

SIMMONS BIT

Drill	Gauge Starting	Gauge Finish	Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per. Min.
1	2-3/8	2-3/8		6-1/4	14-3/4	
2	2-1/8	2-1/8		6	17-1/4	
3	1-29-32	1-7/8	1-32	7-1/2	22	
4	1-49-64	1-3/4	1-64	3	10	
5	1-5/8	1-5/8		10	16-1/2	
			3-64	32-3/4	80-1/2	2.46

The above tests made by drilling holes three inches apart, and otherwise under as nearly as possible equal conditions. The time shown was the actual time while drill was running, all stoppages, whether for changing drills or other causes being deducted.

The following tests were made with an air pressure of seventy pounds as recorded at the air compressor.

Test No. 1.

CROSS-BIT. 2–⅞″ MACHINE.

Drill	Gauge Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per. Min.
1	6-64	8–½	9–¾	
2	5-64	11–½	12–¼	
3	6-64	21	18–½	
4	6-64	18	15–½	
5	4-64	13	12–½	
6	4-64	15	17–¾	
	31-64	87	86–¼	.991

SIMMONS BIT. 2–⅞ MACHINE.

Drill	Gauge Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per. Min.
1	4-64	8	10–½	
2	2-64	7–½	9	
3	2-64	10	13	
4	3-64	10	13	
5	5-64	7	9	
6	2-64	7–½	10	
7	4-64	10–½	14	
	22-64	60–½	78–½	1.297

Test No. 2.

CROSS-BIT. 3¼– MACHINE.

Drill	Gauge Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per. Min.
1	8-64	9–¾	8	
2	12-64	15	18–½	
3	6-64	12	12–½	
4	4-64	9	13	
5	6-64	11	16–½	
6	3-64	10	15–½	
	39-64	66–¾	84	1.259

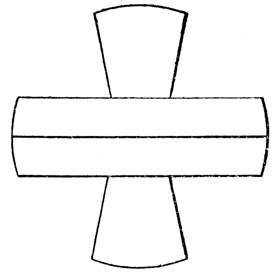
SIMMONS BIT. 3–¼″ MACHINE.

Drill	Gauge Loss	Time Mins. Drilled	Depth Ins. Drilled	Speed Ins. Per. Min.
1	7-64	9	12–½	
2	4-64	8–1-6	12	
3	4-64	10	14	
4	5-64	8	12–½	
5	4-64	10	15	
6	2-64	8	15	
	26-64	53–1-6	81	1.524

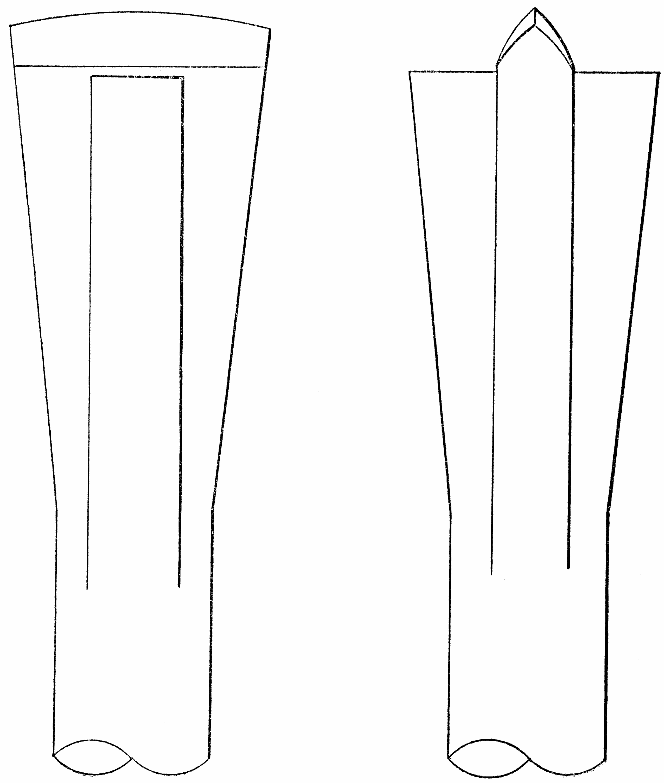
Test No. 3.

CROSS-BIT. 3-½″ MACHINE.

1	8-64	18–½	20–½	
2	8-64	13	23–½	
3	2-64	13	24	
4	2-64	7	11	
	20-64	51–½	79	1.534



SIMMONS BIT.



SIMMONS BIT. 3–½″ MACHINE.

1	3-64	6	7	
2	2-64	7–½	11–½	
3	4-64	7	13	
4	6-64	5	9	
5	1-64	6–½	12–½	
6	2-64	8	16–½	
	18-64	40	69–½	1.738

From the results of these tests I have drawn the conclusion that the Simmons or Reaming bit is the superior of the Cross, or any other bits for hard drilling ground, up to a certain point, that is, up to a point where the application of sufficient power is put behind the Cross-bit to admit of its doing full and effective service with its very large cutting surfaces. Based on the data arrived at, I assume that this point would be reached with a drilling machine whose diameter of cylinder would be four inches. As increased power is used the Cross-bit shows increasing efficiency, but under the conditions now prevailing, with machines of like power, and where the ground is hard, the new Simmons bit will be found to be, I believe, very much superior to any other bit yet constructed. We know of no objections to it on the score of preparation or re-sharpening, as both of these are just as easy of accomplishment as with the ordinary Cross-bit.

MR. FITCH’S PAPER OPEN FOR DISCUSSION.

MR. BALL: I would like to ask Mr. Fitch if this test was made on dry or wet ground, or if any test was made on dry ground.

MR. FITCH: All these holes were downright holes or nearly so. We tried no dry holes at all. I should think the reamer bit might be expected to do even better service in this latter case because we all know that a dry hole is much more destructive on the guage of the drill than any other form, and I believe that with this large reaming surface the new drill will give better results with dry than with water holes.

MR. THOMPSON: I would like to ask Mr. Fitch as to the end of the reaming portion of the bit. Is that formed to be a cutting edge?

MR. FITCH: Only as a reamer. The reaming part of the bit sets back from the cutting edge five-eighths of an inch, and therefore relieves the cutting bit of almost all the necessary reaming work. The edges of the cutting bit necessarily present insufficient surface to withstand the excessive wear or to perform the office of reaming, and in this respect we claim the new bit excels, because of the broad surface presented in the two reaming shoulders.

MR. POPE: Have they gone into general use in the Champion Mine?

MR. FITCH: I think we have used them thirteen years, although I called them novel.

COLLEGE VIEW OF MINING GRADUATE.

BY PRESIDENT F. W. MCNAIR OF THE MICHIGAN COLLEGE OF MINES.

For many years the world of technical training left quite out of account mining and its related industries. There were technical courses for the civil, mechanical and military engineer, but the man who would mine was supposed to dig his skill along with the product which he was mining.

In the years since the Columbia School of Mines began its pioneer work in this field a great deal has been accomplished. Today the Mining college has a recognized place and the boy with mining engineering inclinations usually tries to secure a technical training suited to his purpose.

This would seem to imply that it is fairly settled that the mining graduate has an assured standing with the world in which he expects to make his way and in which he hopes to rise to a position of usefulnes if not of honor. On close inquiry, however, there does not appear to be that accord of opinion concerning him and his usefulness which is thus implied and which one might think could reasonably be expected to exist. And it further appears that this lack of accord may exert considerable influence on the relations between the managers of mining operations and those who hope to get employment with them. With reference to their attitude towards technical graduates, mine managers exhibit two extremes.

On the one hand is the man who without school training himself has an exaggerated estimate of its advantages and results. He thinks the mining engineering graduate should know everything to be known about mining, and should have the ability to do everything there is to be done in the best possible way, and off-hand at that. By glancing over the geology of a region he should be able to tell what it contains of value, how to get it out and how to prepare it for market, all with the greatest degree of economy. Once convinced that he is dealing with a technical graduate this man will trustfully confide to his care the most difficult problems of geology, mining or ore treatment. In consequence when this over credulous person finds out that the idol he worships is but clay after all, he is apt to go at once to the opposite extreme and assert that technical graduates are frauds for he has tried one and proved them so.

This institute is made up of men who can at once appreciate how absurd is the extreme credulity I have described, and, lest you should think I draw too much on my imagination for the picture, I desire to quote from a letter received within a twelve month from one of our graduates. This graduate had been employed by a Mr. S. to assist him in developing a small property of which he is chief owner. At the end of some six weeks of work the graduate wrote me as follows: "——— Mr. S. supposes, or at least supposed, me to be a compendium of all useful knowledge both theoretrical and practical relating to mines, mining and metallurgy. He had the notion that he 'didn't know anything about mining,' hence his engaging me. Except for the knowledge of rocks and minerals, little of which is necessary for this proposition, Mr. S. is fully as capable and even more so than I to develop the property. He can break ground better than I can, and he is an adept at all kinds of rough engineering * * * I discovered the first week of my work that I was not needed here and told him so, but he would not see it that way then, nor has he yet." In this particular case it seems that Mr. S. is likely to reach a just estimate of the usefulness of the technical graduate without at any time losing entire faith in him.

Even the manager who is not credulous often finds fault with the graduate or the school which produced him because there is discovered some detail of craft which has not been learned at college. He seems to think that since the school has failed to teach the particular details in question its product cannot be of much account.

On the other extreme from the over credulous man, but like him without training from the schools, is the manager who thinks success is reached only by the road he himself has traveled. His notion is that the technical graduate assumes to know all that the credulous man believes he does, but that in reality he knows nothing, indeed less than nothing, of practical use. Such a manager said in substance to a member of the College of Mines staff: "Your college man comes into my office to seek employment with an air which announces that he is conferring a favor on the company by offering his services. He assumes that he can give me pointers on how to run this mine. No, I dont' want him, I prefer a man who has never been in college. He is easier to train for he can he made to see that he doesn't know it all." This man had undoubtedly encountered some poor unfortunate fellow whose ideas with reference to himself needed revision. I do not think the percentage of them among technical graduates is large, but this complaint of over estimation of their attainments is one frequently uttered against them.

Between these extreme positions there is almost every shade of opinion of the usefulness of the mining engineering graduate, Naturally the colleges prefer that a middle ground should be occupied as inasmuch as a just estimate of graduates on the part of their employers will contribute not a little to their success, and therefore to the success of the institution which trained them.

Because of this diversity of opinion I deem it to the advantage of the interests of both the colleges and the mines that there come about between them a clear understanding with refer-rence to the needs on the one hand and the purposes on the other. On the part of the college there should be a clear understanding of the character of the work which the mining graduate is needed to do, whether at the mine, at the mill, or at the smelter. Obviously unless the college clearly appreciates the actual situation on the ground, and the requirements its graduates must meet, the development of a course of training which will fit a man to even approximately meet the conditions is impossible. On the part of the mining interests it seems to me there should be a clear understanding of what the college is attempting to do in the way of supplying these demands and to some extent at least of how it expects to accomplish its ends. Certainly such knowledge would avoid annoyance if not positive money loss. A mutual understanding such as that here contemplated can come about only by an exchange of views and opinions between the parties concerned.

It is with considerable satisfaction, therefore, that I improve this opportunity to present something of the aspect of this relation as seen from the position of the Michigan College of Mines. It is presented in the hope of provoking discussion and criticism that will give us a better knowledge of the way things look from the opposite side. I improve the opportunity all the more gladly since this paper must be addressed directly to a body of men who represent those mining interests which are at present using, and if we can meet properly their demands, must continue to use, the larger portion of our output of technical graduates. Companies represented by members of this body now employ nearly half of all the men ever graduated from the Colleges of Mines. I think I can best present the college side of the matter by outlining what we ourselves expect of the graduate who leaves us to begin to make his way in the mining world. Of course within the limits of a short paper this can be done only in the most general terms.

We expect him to know that he does not know it all. I believe our institution has been in the past fairly successful in this particular. From the time a student comes to us until he leaves, this point receives attention. The attention to it is given not so much in the way of direct instruction or preaching about it, but rather in the way of pointing out incidentally to the main features of his course, the real position in which he will stand when he begins service with some corporation. The effort is to teach him in the most effective manner possible that when he graduates he is but ready to begin, that his course if successful has laid the foundation, but that the structure which may be reared thereon depends entirely upon himself and what he may accomplish after he leaves the college.

The college expects its graduate not to go to the opposite extreme of lacking self-confidence. It expects him to be able to do certain things when he graduates. The amount of experience in actual work, practice work, as it is termed, which he is given during his course, ought to fit him to make himself practically useful to his employer from the start. It is expected that having been through this work, having done it with his own hands, he will not be afraid to attempt to do it or its like when asked by his employer. It is expected that this practical training will develop in him a certain amount of judgment of things, that which is commonly meant by the term “gumption.”

The college expects him not to be “lily fingered.” It is expected that the fact that a job is greasy or dirty, or otherwise uninviting because of its surroundings will not cause him to hesitate at undertaking it if it is the next thing to be done. My attention was recently called to a picture of some students conducting milling operations at a well-known school in this country. It was pointed out that these students were in street dress with the exception that an apron had been assumed to protect shirt-fronts and trousers from being soiled. The visitor to one of the practical laboratories at the College of Mines would meet a very different sight, so far as dress and attitude on the part of the student are concerned. He is taught to attack a dirty job in the garb proper for it and to avoid the interference of unsuitable clothing with good work. Any hesitancy to go at a piece of work because it will result in soiled hands or clothing not only brings the censure of the instructor but the ridicule of his fellows. There remains a tradition among our students of a man who dressed himself in street attire to go underground on one of the mining trips, putting on gloves to protect his hands. The tradition says he never went again. An effort is made to have the students realize that dirty hands and soiled jeans are, in their place, as proper as the immaculate evening dress and white kid gloves.

The college expects its graduate to show reasonable industry. He should not be afraid of long hours or hard work if the situation demands them. That he gets some training in this respect is shown by the fact that the average student works somewhere near 70 hours per week during his course. When I say that no stated number of hours is required by the college rules, and that this load is assumed as a result of the atmosphere in which the student works—as a result of his desire to get the most out of his opportunities—I think I have made it clear that the college has some foundation for its expectation of industry in its graduates.

The graduate is expected to display a reasonable amount of conservatism. It is explained to him in his course that when he finds in some region or district a certain practice different from that which he has learned is best somewhere else, he will most likely find that circumstances have altered the case and that the questionable practice which has been developed in the new district is, under its conditions, the most desirable one. Further, that only after he has made a careful investigation and is certain that he is in possession of all the facts, and then only after he has pondered over the matter until certain that no other conclusion can be justly reached he is warranted in departing in his own work from the practice of the district.

It is expected that he will devote himself to the interests of the company employing him, understanding that in so doing he is in the broadest sense devoting himself to his own permanent advancement. The college tries to impress on him that his best interests cannot be different from those of his employers, that the man who "works for quitting time and pay day" can never hope to rise much above his first position. On the other hand that man who devotes the best there is in him to furthering the interests with which he is connected is certain sooner or later to receive recognition and due reward.

It must not be thought that I am claiming for the College of Mines success with every man graduated on all of the points above outlined. So far as I am aware colleges have found no means of supplying missing elements in a student's character and this institution is no exception to the rule. Nor can a college make sure that no student whose character is defective in some important particular shall graduate from it. It can only set up its standards and do its best that every man graduated shall measure up to them as nearly as possible.

I have but presented in a brief and general way some of the standards we expect to apply to our graduates, and by which we expect to judge them. This has been done in the hope that it may contribute to that mutual understanding which I conceive would be to the advantage of all parties concerned. I hope it may contribute by showing forth something of the position of this particular institution and also by drawing out from the members of the institution discussion and criticism that will help the college to a better knowledge of what is expected of it by the mining interests with which it is most closely related.

PROF. MCNAIR's PAPER OPEN FOR DISCUSSION.

MR. JACKSON: I think Prof. McNair didn't treat us exactly right. He covered the subject so thoroughly there remains nothing to be said.

MR. COOPER: I wish to speak of a graduate of a university, and I think in speaking of this particular graduate there may be one or two who will recognize him. I speak of a man from one of the Eastern Universities who came to Calumet. He was supposed to take up a little later that portion of the work of assaying the mineral. From the mine he came to the smelting works. I think he had assumed the character of a man who knew it all. At least within a week he had suggested a number of economies that would have paid my salary a number of times. He returned to the mine and a remark made by Mr. West shortly afterward will perhaps be remembered by others here. He says Mr. Cooper, what do you think of this gentleman? He reminds me of the planter down south who employed monkeys to pick cotton. This planter went to a fair where they had monkeys to pick cotton and they were doing it nicely and he thought it would be well to get some. He had men train the monkeys and when the feat was accomplished and the monkeys were ready to pick the cotton, he had to have a man to go with each of them to get a day's work out of them. It is the same with this man.

A PLEA FOR ACCURATE MAPS.

BY L. L. HUBBARD.

Some years ago I promised to prepare for this Institute a paper on the need of accurate maps as a preliminary to successful geological correlation. The following remarks, with a somewhat different title, are meant to fulfill that promise:

One of the first steps that is or should be taken by the explorer of new and unknown territory, especially by him who intends to leave to the world a published record of his explorations and to give to his readers a means of following him intelligently, is to make a map, accurate or crude according to his ability and to the nature of his journey.

It must ever be a matter of surprise that early voyagers traversing lakes and rivers, shut in from the sight of anything beyond their immediate shores and banks, were able with the aid only of a common compass, perhaps, to make such truthful outline maps as they have left us of the regions visited by them. The map of Lake Superior ascribed to the Jesuit Fathers, Allouez and Marquette, is probably one of the most familiar examples of the kind that you will call to mind. We may well wonder at its accuracy, when we consider the time at which, and the circumstances under which, it was made, and the probable absence of those instruments of precision that are familiar to the surveyor of to-day. No less striking to the lay mind at least, is the great approach to accuracy with which an intelligent woodsman in modern days can map lakes, water courses, and other topographic features, even in places where the U. S. Government has not gone before him with its surveys. In areas where the land has been laid off into townships and subdivided into sections, there need be no difficulty for such a man rapidly to examine each section and draw a map that in its broad features will be very accurate, and in many of its minor details, hardly less so. If in addition to his pocket compass he uses a pocket barometer in connection with a recording barometer left in camp, he can even trace contours on his map that will be accurate to within about five feet—sufficiently accurate for preliminary railroad surveys and useful in hydrographic work. Of course it must be understood that the chief value of work of this kind lies in the cheapness and rapidity with which it can be done, and that the smaller the area to be covered, other things being equal, the less in magnitude are the errors likely to be. Where a considerable area is to be mapped, unless there be permanent land marks in or near it, either natural or artificial, on which the work can be checked as it proceeds, the minor details may even in this case be as accurate and the broad topographic features be made equally as plain, as in a smaller area, but the axis of a mountain range, or the strike of particular rock beds, might be just wrongly enough laid down as to cause confusion—not to the public in general— but to the specialist.

The most useful land marks to the map maker in a forest-covered area are those left by the U. S. Linear Survey, the bearing-trees or witness-trees that mark the positions of the section corners and quarterposts. I say “that are most useful” without mental reservation, although I mean presently to make some qualifications, not of the system, but of the way in which it has been carried out in some places.

It is probably known to many of you that in laying out the lands of the State, the Linear Survey had the township lines run very carefully by picked parties of surveyors by aid of the solar compass, east and west correction lines being run every 60 miles north of the base line which runs from Lake St. Clair to Lake Michigan along the north side of Wayne and Van Buren counties. The principal meridian runs on the east side of Hillsdale county and through the east part of Cheboygan county. Almost all townships and ranges m the Upper Peninsula are therefore referred to as north and west. These parties also established section corners a mile apart on these lines.

The subdivision of the townships was let out on contract, often to the lowest bidder without reference to his qualifications, or apparently, to his honesty. He was supposed to begin at the south side of a township, at the first section corner already set, next west of the N. and S. township line, thence run one mile north setting quarter post and corner, thence east on a random line to the east side of the section—in this case, the township line—where he would correct his run on the corner previously established here, and run back from this corner, blazing the line and establishing his quarter post, to the northwest corner of the section. Blazed trees are supposed to have been within reach of the axeman walking along the line of sight. Where this line actually touched trees they were blazed and notches cut above and below the blaze. They were called sight trees and were generally so few as to be of no service to a compassman trying to check the direction of the line. This process was repeated until the last or north tier of sections was reached, when the line was run straight to the corresponding section corner on the next township line. Any overplus or shortage in the total northing and southing was noted in the length of the west line of the northernmost section and expressed in the acreage of the most northerly “forty” as marked on the map. This process was repeated for each north and south tier until the west side of the township was reached, when the total error east and west was aggregated in this tier. Here also the acreage marked on the map shows the overplus or shortage. No details within the sections were supposed to be given by the surveyors, except perhaps where the section lines crossed ponds, when these were meandered. The surveyor was obliged to make oath to the correctness of his work, as shown by his notes. In the notes of this district we rarely find recorded more than a trivial deviation from 40 chains for the distance from corner to quarter-post, or 80 chains from corner to corner, and yet one instance is known to the writer where a section line is only 70 chains long—i. e., 660 ft. short. In another instance, going north from a section corner, the first half mile led over a very difficult country, where deep ravines and sharp ridges alternated in quick succession. The position of the quarter-post was nearly, if not absolutely, correct, but from the quarter-post north to the next corner, where the land was almost flat, the distance was about 562 feet short.

I show herewith a diagram (Fig. 1) of several section lines in T. 52, R. 36, with corners and quarter-posts arranged in such disorder as to make one wonder how they could have been located; the dotted lines indicate the positions those lines and corners would occupy, if each section were exactly one mile square, as they are usually represented on township and other maps, even on those issued by the Land Office. Indeed without a finished and accurate survey, that is the only way they can be represented.

By means of these section lines and corners, and aided by the field notes, a man accustomed to the woods can always locate himself approximately without great loss of time, and if he may rely upon the accuracy of the section lines and corners he will be able to make a map of the interior of the section that will be accurate for all practical purposes. If he has faith in his own pacing, he can apply the necessary correction to his “runs” when he finds that they are not more than 20 paces long or short between section corners, i. e., his error will not exceed one percent. But not every man that essays to map a section of forest land is a good woodsman, and not every good woodsman will be willing without more ado, to assume, when figures do not tally, that his figures are right, and all others wrong. Indeed the tendency is generally the other way and a conscientious man will want to pace the ground over at least once more to satisfy himself that he has not inadvertently “dropped” a hundred or more paces, or that, from being in a hurry, he has paced long, or because of fatigue near the end of the day, his paces have been short. To retraverse the ground in this way is often impossible, seldom pays, and is never agreeable. It means three miles for one. In a region where the work of the U. S. Linear Survey is known to have been accurate, the topographer can at once discard that most perplexing factor, want of confidence in the section corners, and ascribe to personal equation any apparent discrepancies in his work, and make his corrections accordingly, or repeat his run, if he prefers. It is, however, to work in new and untested areas that I wish to call your attention, especially from the standpoint of the explorer or geologist, and I shall still further restrict my observations to-night to the copper district on the south shore of Lake Superior. I couple explorer and geologist together here, because, in order to attain success more rapidly, the attempt to locate certain copper-bearing horizons should be accompanied by a certain amount of geological knowledge. A great deal of money and energy may be wasted by a good miner, by digging in the wrong place.

I think we are ready to admit (First) that without some preliminary subdivisions of the land into definite units, no accurate detailed mapping is possible in a forest-covered area, unless with the outlay of much time and money. The work to be economical should properly be done by specialists in advance of geological investigation. (Second) Where an area to be investigated by the geologist has been subdivided into sections by the U. S. Linear Survey, the record of that survey may be correct or incorrect. If it be found to be incorrect at any one point, some other section corners or quarter-posts not far away must also be wrong. I shall try to show that not only must these be checked, but that the geologist, once put on his guard, must be ready to check all other important points. In fact he cannot be sure of his ground, until he has established the amount of error in the setting of all the section corners and quarter-posts, and the consequent courses of the section lines, in the area under investigation.

I need not go into a description of local geology any further than to say that our copper deposits are contained largely in beds of direct volcanic origin that extend along Lake Superior nearly parallel with the shore line and with each other, dipping towards the lake at different angles. These beds consist of old lava flows and interbedded and sedimentary rocks. The sedimentary rocks—conglomerate and sandstone—vary in thickness from small seams up to beds 2500 feet thick (the Great Conglomerate). The lava flows—traps with amygdaloid margins—are seldom individually of great thickness, but successive sheets may aggregate a considerable thickness—much greater than is common to the conglomerates. The great majority of trap beds are to the naked eye indistinguishable from each other, and being in zones usually much wider than the conglomerates that occur on each side of them, and not being, as a rule, as continuous as the conglomerates, it is in general more difficult to trace any one trap or amygdaloid bed in the field, than it is a conglomerate. The lava flows that now constitute our trap beds, if considered as running down a slope, were limited in lateral extent. Those of Hawaii are about a mile wide, and sometimes as much as forty-five miles long. Those of Keweenaw point may have been much wider, when they reached and spread out over flat ground. Several outbursts from the same source may have run towards lower ground through several shallow channels. Hence, these flows, taking place at about the same time and composed of similar material, really constitute the same bed, but the bed is discontinuous. The intervals between the parts may be considerable. Where such a bed is now the repository of copper, the explorer wishes to trace it, and the geologist seeks to aid him. How shall it be done? The surface of the rocks is hidden by thick accumulations of drift or “overburden”; only here and there do the rocks reach the surface. Perhaps the bed in question is interrupted not far from where it was last opened up. Shall shafts be sunk at intervals through the heavy drift in search of the coveted bed? No, this is too expensive. It is cheaper to use the diamond drill, but perhaps this is not yet necessary.

We know that the intervals even between conglomerate horizons are not always constant for long distances. The forces of erosion that produced our conglomerates may be said to have been fairly continuous along the entire sea coast of ancient geological ages. Their record was simply interrupted and temporarily obliterated by the more violent forces of eruption, sometimes at one point, sometimes at another. Near the end of Keweenaw Point three conglomerate beds, separated at their widest parts by lava flows, merge into each other towards the west. Here, at least two flows of lava at different times were poured flown the lower part of a trough, over conglomeratic material, leaving the latter uncovered on the highest parts of the sloping sides of the trough. We must be on our guard then, in correlating conglomerates, not to insist upon a rigid parallelism of beds, i. e., a constant width of the intervals that separate them. It is only by feeling our way, as it were, over the ground, that we can best avoid mistakes. Again, in one part of our area there may be known only a certain number of conglomerate horizons. Others may be there but may be hidden. Or, these may have been interrupted, just as the trap beds are interrupted. You will find on our lake shores to-day sand and pebble beaches interrupted by ledges of trap. If, then, we find in adjacent areas, conglomerate or sandstone beds where they are not expected, their presence does not necessarily vitiate the accepted correlation. They must simply be interpolated in our series as it is known elsewhere, and may be designed provisionally by fractional numbers if we will.

Where investigation proceeds from known areas, where not only the beds that carry copper in paying quantities, but the individual conglomerates are pretty well known and located, if the intervals between the latter are not too small, we can seek to follow any particular conglomerate or conglomerates, and if their outcrops can be traced from point to point, we thus know approximately how far to the right or left is the horizon of the particular amygdaloid bed we are seeking. At the risk of being personal, I may explain that this method was followed in locating the extension of the Baltic lode on copper range lands. This bed, where opened by the Baltic company, is about 114 feet horizontally northwesterly from a thin bed of sandstone and conglomerate, that dips northwesterly about 70 degrees or more. This conglomerate, for good reasons not necessary to repeat here, is supposed to correspond to conglomerate No. 3, of Marvine (Geol. Sur. of Mich., Vol. 1.)

Where exposed near Houghton this bed, No. 3, is probably at least 1400 feet from the nearest conglomerate on either side of it—thus leaving intervals of trap rock wide enough to avoid any confusion in the correlation, always supposing, of course, that no new conglomerate beds, unknown at Houghton, would appear within the series at points further southwest, and thus destroy the supposed sequence. Between Houghton and the Baltic mine the strike changes from about S. 35° W. to S. 60° 30' W. If the Baltic lode were to continue with the same strike from the Baltic mine for two and a half miles further to the southwest, its course would take it nearly through the center of Sec. 25, T. 54, R. 35. Beyond the Baltic mine only two isolated outcrops of trap were mapped in Sec. 30 and one in Sec. 31, so that the course of the formation there was unknown. On the strength of the supposed course of the Baltic lode the Board of Supervisors in 1899 assessed Sec. 25 at $194,000 and the W. ½ of Sec. 31 at $32,000 and Sec. 36 at $64,000, although just on what grounds the last two parcels were considered worth $100 an acre is difficult to see, if the Baltic lode was thought to pass through Sec. 25, to the west of them.

On the melting of the snow in 1899, the writer, with a view to find, if possible, a conglomerate, examined Sec. 31, and found not only a series of trap outcrops, but a bed of conglomerate a few feet wide in the northwest quarter of the northeast quarter of that section. Enough of this bed was exposed to give an approximate strike of N. 26° E. and a dip of about 700. In thickness, character and dip, this bed corresponded fairly well with the conglomerate on the Baltic location. No other conglomerate could be found within 1200 feet west of it, and from the rapid falling off of the rock surface to the east, the general character of the topography resembled that of the other parts of the series near the junction with the Eastern sandstone, i. e., to the east of the Baltic conglomerate. Moreover, it was known that in T. 52, R. 36, to the southwest, the strike of the series was almost northeast—southwest and that from the position of certain beds there, the series must curve to the east, coming north, in order to get into line again, but just where this curve—or these curves if there were more than one—would occur, was not known, because of the heavy mantle of overburden that covered the intervening area.

By platting the course of the conglomerate in Sec. 31 towards the northeast, it was immediately evident that to get into parallelism with other beds of the series further north, this bed must, within less than two miles, curve more to the east, and the least violent assumption was to curve it into the Baltic conglomerate, rather than to carry it 1200 feet or more to either side of that bed. To carry it to the east of the Baltic bed would require a greater curve over the intervening 2½ miles, while to carry it to the west would in the end require even a greater change of course—within a much shorter distance. On the assumption then that the two conglomerate outcrops, that on the Baltic and that on the Copper Range, were parts of one and the same bed, steps were taken to uncover the ledge towards the west, and at about 190 feet horizontally from the conglomerate the bed was opened that is now worked by the Champion and Trimountain Mines, as the Baltic lode. The distance from the conglomerate is about 75 feet greater than at the Baltic mine, and the bed where opened on the Champion location more than a mile from where it would be if it maintained a uniform strike for 2½ miles southwesterly from the Baltic.

In the face of conditions like these, it might very pointedly be asked, of what service to the explorer will be even the most accurate of maps. The reply would be that the case under discussion is exceptional both in the abruptness of the change of strike, and in the want of outcrops. In general in the Portage Lake area, there are long distances over which the strike of the beds varies but little, and in other areas like that of Allouez Gap, outcrops of several characteristic beds betray the change of strike, and in the Rockland area the topography furnishes the key to the geology.

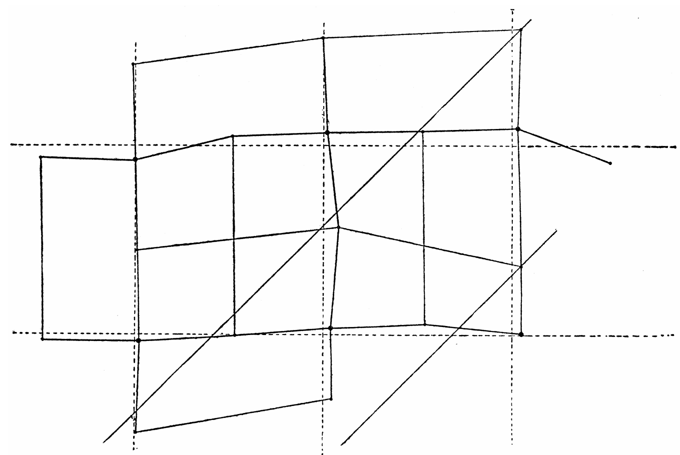
Where Nature has laid bare her secrets in these or in other equally readable ways, the explorer has little immediate need of a map of any kind. It is for use in those areas of a mineral district where no mineral deposits have as yet been uncovered, and where outcrops have never been correlated with beds known at other points, that an accurate map may be of great service.

Now, referring again to our diagram, supposing a copper-bearing bed has been opened near either of the quarter-posts on the east side, and its strike there is known to be S. 45 °W. Suppose also a lake or series of lakes and swamps lie along the line of that strike, ending with high drift-covered hills like Wheal Kate back of the Atlantic Mine. We wish to use a diamond drill from one to two miles further southwest for the purpose of locating the extension of our copper bed. Inasmuch as drilling costs from $2 to $4 per foot, or more, we wish to locate our drill as nearly on the line of strike as possible, so as not to have to drill through any ground unnecessarily. Two ways are open to us, (1) to run a transit line from the point where the bed is being worked, going around the lakes and cutting through the swamps, or, (2) to plat on our map, with reference to the nearest section corner, two points of the bed where it is being worked, prolong on the map the strike line to the other section where we wish to begin operations, and by scaling from the map determine the coordinates of two points in this line with reference to the nearest section corner or quarter-post, and then stake off the line by pacing or taping from the corner or quarter-post. The second method seems much the more direct and the less expensive, but unless our corners and quarter-posts are correctly located and our elevations known, we may be so far away from the true line of strike that we shall put down at least one drill hole to no purpose, and at considerable expense. We have already noted an error of this kind of 660 feet in one section, and if we have to cross several sections with our line, the error may be much greater. In the case before us the error might be as high as 1280 feet. If, however, the section corners and quarter-posts were originally correctly located, or if their actual position with reference to each other has been subsequently determined, we can proceed with our work with every confidence that so far as known or knowable facts are concerned we are exactly where we should begin to drill.

You will thus see that exploratory work would be made much less expensive were the public in possession of a map that simply showed the section lines and corners correctly. I am now prepared to go one step further and say that maps giving these data as well as contours should be made at public expense. This statement, in order to carry general conviction with it, need be reinforced only by repeating that the interiors of the sections carelessly outlined by the Linear surveyors were not examined by them and are hopelessly wrong on the Land Office maps. By the mine manager, however, I am sure a contour map will be appreciated, after he has found his mineral, and is preparing to locate his shafts and bring a railroad into them, to lay out building lots with an ample and convenient sewer system, to carry roads through his location with easy grades, to lay water pipe or launders, to locate a stamp mill, coal pockets, etc. To do all these things harmoniously, to plan the whole system at one time, is, I venture to say, absolutely impossible without a contour map, but with it the engineer can sit in his office and lay out a good preliminary plan of the entire plant, without a single visit to the location. Of course, for detailed work of this kind a map is needed on rather a large scale with contour lines more frequent than they are usually placed on maps published, for example, by the United States Geological Survey, i. e., 20 feet vertical distance, and the subsequent construction of such a detailed map must fall upon the individual or company. But even on the smaller scale such maps may be useful to the public at large; in laying out railroads, steam and electric, water ways, highways, dams and reservoirs, drainage and sewer systems and other public works, and if made by a trained corps of engineers, can be made with a fraction of the expense, and in a short part of the time that would be required by individual and intermittent effort. Besides, they would form symmetrical parts of one system, instead of being disjointed, disconnected and fragmentary parts of as many different systems.

Individuals or companies, when they do make maps of their properties, are apt to start from independent data that are afterwards found not to be reconcilable. Their maps are not published. The few copies made are exposed to loss by fire, and other causes, sometimes by the failure and dissolution of the companies. The copper district of Michigan is closely dotted with old mining locations. Where are the maps of the old companies? About every change of ownership of land on the copper range is apt to call for a new survey and a new map. One systematic survey of the state would put an end to this recurrent expense, and would give us once and for all, a correct, harmonious and useful map.

With a view to assist in the work of correlation along the copper range south of Houghton, and to correct some of the faults of the earlier land survey in that area, the Geological Survey of this State, some years ago, made a traverse survey along the Ontonagon road between Houghton and Rockland, and leveled over the road, establishing bench marks near every section line. It also tied on to the nearest section corners and quarter-posts by an accurate transit survey. By referring to any of the above bench marks, the elevation of any adjacent point can easily be determined, and the co-ordinates of any section corner can be established with reference to any known point along the road. The cost of this work ran up into the hundreds of dollars. The cost of estimating standing timber is, I believe about five cents an acre which is certainly less than it would cost a mining company to make a contour map of its property. The United States Geological Survey has mapped large areas, in fact entire states, at a cost of one cent an acre, and then this cost was divided between the United States Government and the respective states. So much for system.



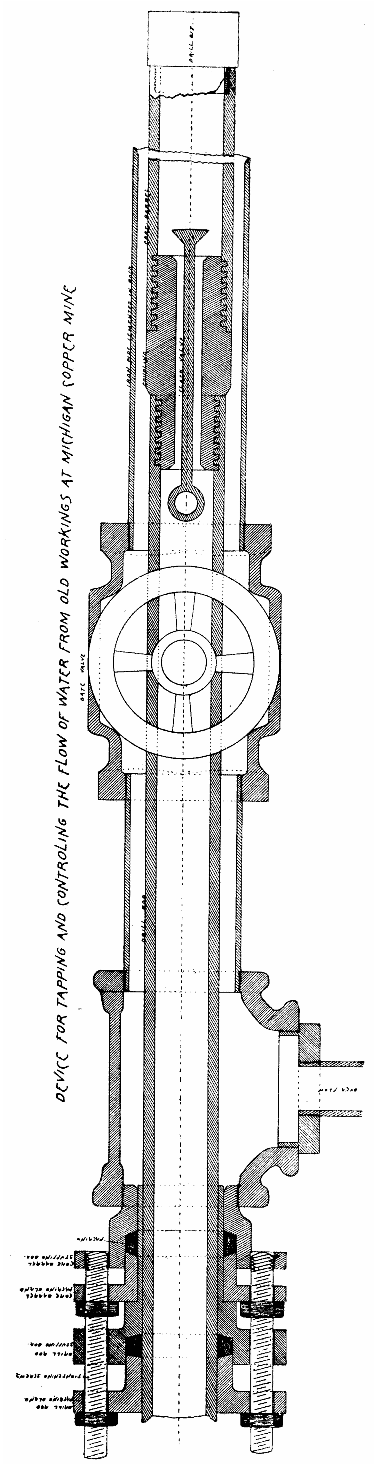
MAP SECTION.

DR. HUBBARD'S PAPER OPEN FOR DISCUSSION.

DR. LANE: I will remark that a bill is now before the legislature to have such a map as Dr. Hubbard mentioned, made at the joint expense of the United States and the state. In this work of course the co-operation of all individual surveys will be desired and welcomed if the map is put through. It is not competent for the Institute as a body to pass on the matter but the individuals should express themselves to their representatives. One point which Dr. Hubbard raised is of importance, that is, the getting together and showing new results collected. Explorations on one property, which may be entirely without value may have a very important geological bearing upon the value of some other piece of property.

Each explorer or exploring company should have accurate maps of their own work, and the State

Geological Survey furnish a base line upon which they can all be framed together and correlated.



TAPPING THE WATER IN THE OLD MINNESOTA MINE.

BY S. HOWARD BRADY.

This is a description of the method used in tapping the water in the old Minnesota Mine by a series of diamond drill holes, bored from each level on the Calico vein of the Michigan Copper Mining Company at Rockland, Michigan.

No especial originality is claimed. A casing, consisting of a piece of 2½" wrought iron pipe, was set in a hole 3½ feet deep drilled in the foot wall at right angles with the dip of the vein which is about 46 degrees with the horizon.

The hole was drilled with a No. 3 Little Giant Rand Drill with 3½" bit; the hole was then run full of neat Portland cement, a thin wooden plug was placed in the lower end of the casing, and the casing pushed in the hole and firmly wedged with iron wedges.

Two small holes were drilled on either side of the drill hole, anchor bolts driven in them, and a clamp put around the casing and fastened to the bolts for extra security against the water pressure forcing the casing from its place.

The cement was allowed to set until thoroughly hard. We then drilled a 2" hole until striking the water, which was easily told by the increased flow of water from the waste pipe in the Tee shown in drawing. The valve on the waste pipe was then partly closed and the rods allowed to come up which they did very nicely, being assisted by the water pressure to such an extent that it was necessary for two men to handle them with tongs, allowing the tongs to strike against the chuck of the drilling machine, each man letting go and taking a new hold alternately.

After the water swivel was disconnected, the valve situated in the connection between drill rods and core barrel kept the water from corning through the rods.

They were then drawn up until the shoulder of the core barrel connection came in contact with the stuffing box. The top nuts on the stuffing box were loosened and the small stuffing box removed, leaving space for the core barrel to pass through the larger stuffing box. The last rod was then disconnected; and the core barrel drawn up until the bit passed the gate valve, which was then closed. The core barrel and bit were removed and the operation ended. Up to date we have drilled two holes without the escape of any quantity of water and without the wetting of a man, the water pressure being 57 pounds to the inch at the time the water was tapped.

The operation is a very simple one and worked in every way to our entire satisfaction.

ERRATA.

Page. 44,10th line, "6" per cent should read .6.

" 46,1st " 5th paragraph, "1877" should read 1887.

" 52, 5th " first word, "two" should read four.

" 53, 26th " "20" feet should read 29 feet.