whole mass of blood; have had enough effects that way, if it do not bring on a putredenous thinness." This was evidently but supposition; the serum of the blood or the white of an egg, requires a degree of heat to coagulate, which no living animal can bear, notwithstanding the puzzling tricks of fire-eaters and such mountebank impostors, who thrust themselves into ovens heated sufficient to bake a leg of mutton. Water at 108 degrees is too hot for the hands for any length of time; yet there are some persons, from custom, who can handle very hot pieces of iron; but such instances are only sufficient to form an exception to the rule and require no further comment."

Dr. Arnold records several fatal cases in which the temperature ranged from 108 to 110 degrees in the axilla. In three cases of yellow fever recorded by this physician, the temperature reached 110 degrees, and a similar degree of heat was observed in several cases during life by Dr. Bennet Dowler in 1843, 1844 and subsequently. In 1843 he began a remarkable series of investigations on the temperature of the heart and axilla during the various stages of yellow fever, and of the different organs after death. His original paper was first transmitted to, but not published in full in the *Western Journal of Medicine and Surgery* during the winter of 1843-44. Dr. Dowler continued his observations on the temperature in yellow fever and other diseases during a period of sixteen years,³⁴ and he established the fact that the temperature of the internal organs may attain after death a degree of heat equal to that witnessed by Dr. John Davy in the Island of Malta in 1828, viz., 113 degrees. Dr. Dowler confirmed the accuracy of the statement of Dr. Arnold, of Jamaica, that the temperature of the axilla in yellow fever may reach 110 degrees F.; and he also demonstrated that patients may recover from yellow fever whose temperature in the axilla has reached 109 degrees.

Dr. Dowler also demonstrated that, as a general rule, the temperature in the early stages of yellow fever is higher in fatal cases than in those which recover. Thus, in one series of cases of yellow fever, taken without selection, the following results were obtained: Fifteen patients who recovered, whose temperatures were taken at a period which averaged fifteen and one-third hours after the invasion, and afforded a mean temperature for the hand of 101.8 degrees, and for the arm-pit 104.84 degrees; nine persons who died, gave an average of, twenty-two and one-third hours after the invasion, for the hand, 103.62; for the arm-pit, 105.44 degrees.

The maximum of these classes coincided, but not the minimum. In those who died the average was higher; in the hand, the maximum reached by both was 107 degrees; the minimum in the hand among those who recovered was 95 degrees, and of those who died 99 degrees; the maximum of the former, in the axilla, 107 degrees; of the latter, 109 degrees; the minimum of the former, in the same region, 102 degrees, and of the latter 100 degrees, the latter being in *articulo mortis*.

Full justice will be done to the labors of Dr. Bennet Dowler in that portion of this chapter which relates to *post-mortem* heat in yellow fever.

Dr. Daniel Blair,³⁵ in his last published report on

the "First Eighteen Months of the Fourth Yellow Fever Epidemic of British Guiana," says: "High temperature of the body seems to have persisted longer through the stages of the disease in this epidemic than in the past. There is great irregularity in the temperature of the surface; sometimes the forehead is the hottest part of the body, and occasionally the chest. The uncovered portions of the body in the latter stages are easily reduced in temperature; and thus while the exposed chest and extremities may feel cool to the touch, the axilla may raise the thermometer to 102 or 103 degrees. The highest temperature I have observed during the course of the disease was 107 degrees Fah."

According to Dr. Wragg,³⁶ in some cases of yellow fever, the thermometer indicated a temperature of 108 degrees in the arm-pit, and 105 degrees on the chest.

Dr. Robert N. Lyons,³⁷ has recorded valuable observations on the relations of the pulse and temperature in the yellow fever which prevailed in Lisbon, Portugal, in 1857. Dr. Lyons arranges the cases under five groups, viz.: 1, the algid form; 2, the sthenic form; 3, the hemorrhagic form; 4, the purpuric form; 5, the typhus form.

(To be continued.)

NOTES ON THE MAIN CHANNEL OF THE SANITARY DISTRICT OF CHICAGO.

Read before the Civic Federation of Chicago.

BY J. W. BEARDSLEY, C. E. (CORNELL UNIVERSITY.)

It is impossible within the few minutes at my disposal to more than cursorily touch upon the following general points relative to the main channel of the Sanitary District of Chicago:

1. A general description of the present progress of the work.

2. Some of the benefits accruing to the residents of Chicago upon the completion of the channel.

3. Points of interest in a tour of the line.

Of the well-known facts regarding the origin of the project, the labor involved in its legal birth and the imperative demands of sanitation for immediate relief, I will say nothing. The existing result is a channel under process of construction and about thirty miles long. The eastern terminus is at the intersection of Robey Street with the west branch of the south fork of the river, the grade of the bottom being about twenty-four and one-half feet below the Chicago datum plane, or the low water of Lake Michigan; thence it extends westerly, through the ancient water course of the Great Lakes to the Gulf, to the lower terminus at Lockport, where the bottom has an elevation of thirty feet below the Chicago datum plane.

The line is separated naturally into four divisions by the cross sections, and by the nature of the material to be excavated.

From the eastern terminus at Robey Street to the lower part of Section F, a distance of about nine miles, the material is of a nature to be readily excavated without interference to navigation or discharge whenever, in the future, sanitation demands a larger channel. Therefore, the area of the cross-section is a

³⁴ Experimental Researches into Animal Heat in the Living and in the Dead Body, by Bennet Dowler, M.D., of New Orleans. New Orleans Medical and Surgical Journal, Vol. xii, 1856, pp. 54, 205, 289, 433, 603, 769, 433, 470; Vol. xvii, 1860, pp. 199, 356.

³⁵ British and Foreign Medico-Chirurgical Review, April, 1856, Appendix, p. 6.

³⁶ Charleston Medical Journal and Review, 1855, Vol. x, p. 73.

³⁷ A treatise on fever or selections from a course of lectures on fever, being part of a course of theory and practice of medicine, delivered by Robert V. Lyons, K.C.C., etc. Am. Ed., 1861.

minimum being held to a bottom width of 110 feet. This section is designed to carry 300,000 cubic feet of water per minute. The average cutting is thirty-seven feet deep.

Near the lower end of Section F, the material becomes more difficult to excavate and is designed for the maximum discharge of 600,000 cubic feet per minute, a quantity sufficiently large to so dilute the sewage of 3,000,000 inhabitants that the effluent will be harmless for manufacturing purposes. Here the cross-section is expanded to 202 feet on the bottom with side slopes of 2 feet horizontal to 1 foot vertical. The maximum velocity is about twenty-one inches per second. The average cut is nearly thirty-six feet for the next five and one-half miles.

The third natural division beginning near Willow Springs, marks the appearance of rock, the glacial drift forming about two-thirds of the material to be excavated. The cut averages about thirty-seven feet. Here the cross-section is decreased to 160 feet at the bottom and 163 feet at the top of the channel giving, practically, vertical sides. Retaining walls, extending from the rock up to five feet above the datum plane, form the sides of the channel. This bottom width of 160 feet controls the remainder of the line. Here, also, the union between the bottom widths of 160 feet and 202 feet is made. The retaining walls extend out as wing walls, to the required form of the preceding section.

The grade has an increment corresponding to the decrease in area of the cross-section and still provides for the maximum discharge of 600,000 cubic feet per minute. This requires the velocity to be increased to thirty inches per second, or two miles per hour.

Near the eastern end of Section 7, begins the fourth natural division; the glacial drift practically disappears, forming only about 3 per cent. of the total excavation for the remaining nine miles. The average cutting through *solid rock* is about thirty-three feet. This unparalleled rock excavation has necessitated the use of channeling machines for cutting vertical sides, drills to prepare the rock for blasting, and various conveyors for removing the shattered rock after it has been loaded by hand into skiffs or buckets. The end of this division and the western terminus of the main channel—Section 15—is partly built up and partly excavated and marks the location of locks, when the channel is finally open to navigation; but for the present it will be the site of the controlling works, by which the discharge of the new channel into the Desplaines River may be regulated. These works must provide for the surface fluctuations in Lake Michigan, which would result in an extreme oscillation of about thirteen feet at the controlling works. The surface of the water at the controlling works is some ten feet above the surface of the Desplaines River, which makes a rapid descent for about four miles to Lake Joliet. It will require extreme care to safely dispose of this immense volume of water over such a declivity, and it also suggests the enormous energy which could there be developed, estimated by Mr. Cooley to be 55,000 horse power between Lockport and Joliet, and 45,000 between Joliet and La Salle. Such a power and such a water-way have caused in similarly located places, phenomenal growth, and may form a source of income to the sanitary district of no mean moment.

The expenditure of \$3,000,000 (actually \$2,606,-

227.92) for a right of way has received its share of criticism. It would be a paradox to find a charitable object or institution, a financial success. But measure, if you can, the development of the city along such an avenue of commerce, the value of adjoining lands, which the trustees with keen foresight have added to the assets of the sanitary district, wharf privileges and warehouse rentals, and show that within the lifetime of some of us this same right of way may not prove a magnificent investment for meeting bonded indebtedness, or, for the expenses of maintenance and development.

The estimated rock excavation on Sections 7 to 14, inclusive, gives a total of 8,189,152 cubic yards of rock in place. This will expand into 14,333,333 cubic yards of broken stone on the sanitary right of way, at the very edge of an extensive water course. This is an amount sufficient to build 3,257 miles of street, having a road bed 30 feet wide and using an average depth of 9 inches of broken stone. It would build 12,217 miles of country road 12 feet wide and with an average depth of 6 inches, thirty-one and one-half times the length of the State of Illinois, from Chicago to her antipodes; or, furnish the foundations, and it would give a path 2 feet wide and 2 inches deep from Chicago to her lunar neighbor.

Financially, it is more economic policy for the taxpayers of the sanitary district to place untainted and above suspicion, their magnificent source of potable water by one large outlay, than to keep themselves perpetually subject to expense in extending water supply tunnels and in the hopeless pumping of the Chicago River sewage into the Illinois and Michigan Canal, which stands a menace to health throughout its entire course, and of which it has been aptly said: "It is frequently worse but never better."

Sanitation is a measure of civilization. Advancement requires time. Public opinion is called safe because it is conservative; but it is dangerously conservative in lines of advanced sanitation.

It is not possible to give a money value to sorrow, to losses entailed by useless sickness and death, and to the increase of crime and pauperism always accompanying filth and squalor, or, to place a value upon increased longevity and good health—the working capital of both unskilled labor and of the leaders in thought and action. But let us attempt to find a money value for a disease typical of polluted water and inferior sewage disposal. From typhoid fever in the years 1890, 1891 and 1892, the State Board of Health reports an average of 1.18 deaths per 1000, and this dread disease has been almost an epidemic here during the past decade.

Of typhoid fever, twenty-eight English cities give an average decrease, brought about by sanitary measures, of 39 per cent. Likewise, Boston, Brooklyn and New York obtained a decrease of 41.5 per cent., and I believe that the workings of the main channel of the sanitary district will bring to Chicago the beneficial decrease of 50 per cent., but to be more conservative, place the decrease at 33½ per cent. Assume a population of 1,500,000 and a reduction of the death rates of 1890 to 1892 by 33½ per cent. and we have a saving of life from typhoid fever alone of 585 persons per year. Assume only one-fifth of these to be bread-winners, supporting the average family of five. The city would save on this basis the support of 117 such families or 468 such persons, costing not less than \$150 a year for five years. This

moderate hypothesis results in an annual saving to the tax payers of \$355,000. To this add a saving of \$25 for each funeral involved, and the moderate fee of \$10 for medical attendance for each of these 585 useless deaths; this gives the sum of \$20,475. Assume ten cases of serious illness for each death, at an expense for medical attendance and enforced idleness of only \$15. This adds to the sum \$87,750. Thus the grand total saved per year by the reduction in typhoid fever alone is \$463,225. This sum capitalized at 4 per cent. per annum gives \$11,500,000, nearly one-half of the total expenditure of the sanitary district of Chicago.

The city of Chicago is located upon the bed of a comparatively recent swamp, and is specially subject to zymotic and enteric diseases, but her death rate *should be below* the normal on account of the continuous increment to her population of men, young, robust and ambitious.

The increased resistive powers of the system, the increase in capacity for thought and work, in morality and independence, resulting from the causes that decrease a death rate, can not be measured by sordid money values. But considered from the above standpoints, we can but feel and admire the wise and intense philanthropy which characterized so thoroughly the early promoters of the sanitary scheme. Aside from sanitation, the national importance for warlike maneuvers, and the international commercial importance of such a watercourse to Chicago can not be passed by. I quote from a brief by Mr. Cooley:

"Sitting at the pass of two continental valleys, a great waterway to the Atlantic, a great waterway to the Gulf, the center of a territory as resourceful as the world can show—her latent interest is awakening; she would restore the ancient outlet of the lakes; her thinking men are realizing that this old portage may become the Bosphorus of America, like the Constantinople of old, to possess which was to rule the world."

To the tourist the massive machinery, almost intelligent in its power, the proportions of the canal already excavated and the corresponding spoil banks attract, generally, the most attention, and are certainly worthy of more than a casual visit.

The huge dipper dredges on the two sections nearest the city, rapidly eat their own channel for floatation. West of these are the inclines, the bridges spanning the spoil banks, the belt conveyors and the cantilever conveyors operated in connection with steam shovels. All are movable parallel to the axis of the main channel, and are effective, ingenious and ponderous machines. Next are found the hydraulic dredges on Sections A and B, east of Willow Springs. Here the soft, low-lying ground is agitated beneath the water surface and, by means of powerful pumps, it is discharged from pipes at the desired distance from the channel. These sections will soon be unwatered, so that the hard underlying material may be excavated by steam shovels and other suitable machinery.

It is doubtful whether the men now engaged on the western portion will ever again see a rock cutting of such magnitude. Here are the cableways of 700 feet span, and the cantilevers which reach out 140 feet over the channel and 180 feet over the spoil bank.

The not uncommon occurrence of a rock blast shattering and hurling perhaps four thousand tons of rock, and consuming nearly a half ton of dynamite, is an impressive spectacle. To the geologist the present state of excavation affords an intensely interesting field. He has an unparalleled opportunity to study the varied constituents and complete sections of glacial drift as it was left in the remote times, cutting its striae and furrows in the underlying rock, and he will perhaps find the cutting boulder still in its abruptly ended furrow. In the alluvial deposits, large antlers, Indian relics, buffalo and mastodon bones have been discovered.

The vertical cuttings through solid rock present vivid object lessons in stratification faults and fissures, and the fossil hunter will be amply rewarded by finding nearly all the fossils characteristic of the Niagara limestone.

When the channel is complete from the standpoint of the sanitary district, Chicago can successfully combat scourges and epidemics. The Chicago River will become an outlet and will gradually purify itself and become a part of the network of lagoons joining the lake and the main channel through the north and south forks.

Chicago is rapidly becoming the first city of the Occident. In present achievements she has surpassed the wildest predictions of her founders. But useless will be her command of commercial centers, of railways and water courses unless she listens to the too apparent warnings of her streets and rivers, provides for her millions those most lavish gifts of Nature—pure air and pure water—and the higher gifts of civilization, pure social, moral and civic conditions.

It behooves every patriotic citizen to be relentless and persistent in the instruction of the masses for the accomplishment of such ends; then will the city of Chicago stand majestically, the Queen of the Western World!

A SKIASCOPIC EYE.

BY JAMES THORINGTON, M.D.
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The rapidly growing popularity of the shadow test as an accurate method of obtaining the exact refraction of an eye under the influence of a mydriatic, prompts the writer to present an inexpensive eye for the use of the student or oculist who may desire to learn skiascopy at his leisure.

The eye as here shown, reduced one-third in size, is made of two cylinders of cardboard, one slightly smaller than its fellow, to permit slipping evenly into the other. Both cylinders are well blackened inside. The smaller cylinder is closed at one end, and on its inner surface is placed a colored lithograph of the normal eye ground. The larger cylinder is also closed at one end, except for a central round opening, ten millimeters in diameter, which is occupied by a +20 diopter lens; and on its outer surface is a colored lithograph of the normal eye with its appendages, the pupil being dilated, and corresponds to the central opening just referred to. In addition to this picture of the eye, there is also lithographed on the upper half of the periphery, the degree marks similar to those on a trial frame. To the lower half of the periphery are secured four pieces of cardboard, making two interspaces for trial lenses, and being square at the base, gives the eye an even resting surface.

On the side of the small cylinder is an index which records emmetropia, and the amount of myopia and hypermetropia according as it is pushed into or drawn out of the large cylinder. To use this eye, it is only necessary to bear in mind the two rules of skiascopy, governing the use of the plane mirror at the working distance of one meter, namely, that the light reflex seen in the center of the pupil moves,

1, with the movement of the light on the face in emmetropia, hypermetropia and in myopia, if the latter is less than one diopter; and 2, against (or opposite to) the movement of the light on the face in myopia of more than one diopter. If it is desired to study the band of light,¹ as seen in myopic or hypermetropic astigmatism, place the necessary cylinder from the trial set, in the back interspace, the degree marks assisting in finding the axis, and especially so if the axonometer is used.

This eye answers admirably for the beginner in ophthalmology, though not originally so intended, and as here illustrated and described, is made by Messrs. Queen & Co., of this city.

¹Vide, *Annals of Ophthalmology* for January, 1895. "Thorington on Skiascopy."