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OF GENERAL INTEREST

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BASIC HYDRAULIC TRANSIENTS

BY GEORGE R. RICH, MEMBER*

(Presented at a meeting of the Hydraulics Section of the Boston Society of Civil Engineers, held on February 4, 1948.)

Because the differential equations of water-hammer and surge tank theory are not integrable for the boundary conditions imposed by most practical problems, hydraulic computations in this field are frequently performed by a trial-and-error step process known to the trade as arithmetic integration. It is interesting to review the correlation of the comparatively few basic ideas underlying the application of this useful device to the study of pressure conduit acceleration and turbine speed regulation.

The fundamental action of water-hammer can be grasped intuitively by considering the case of the simple conduit under instantaneous closure of the outlet valve and with conduit friction assumed equal to zero. In Figure 1 for the direct positive wave, first the velocity of the water immediately adjacent to the valve is extinguished to zero; the head in that immediate vicinity is elevated above the steady-state or reservoir head; locally the conduit is distended above the steady-state diameter and the water compressed above steady-state density. The volume of water that would normally have passed this infinitesimal length of conduit is stored in the space so provided. This process of extinguishing conduit velocity then progresses upstream with the speed of sound.

For a fleeting instant when the wave front reaches the reservoir, the entire conduit is above reservoir pressure and at zero velocity; the

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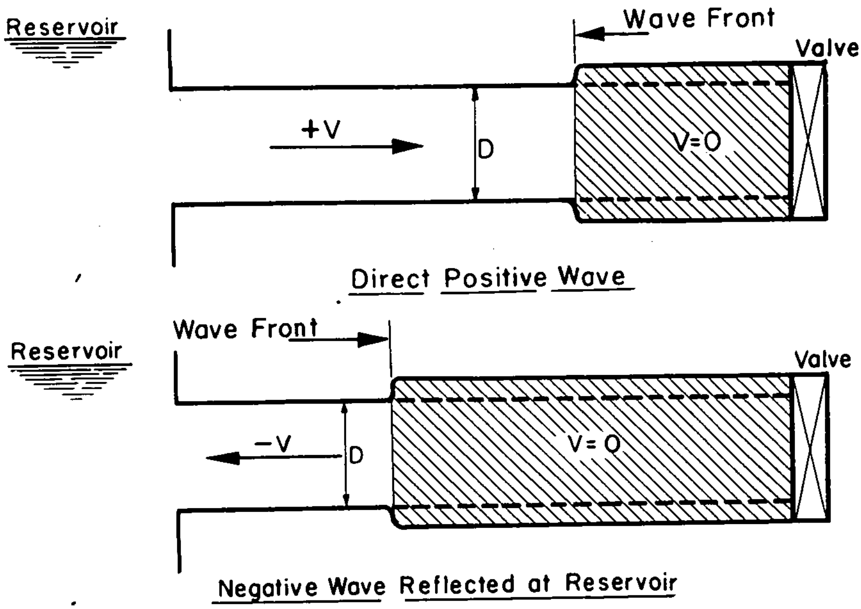


FIG. 1

conduit is distended and the water compressed. The subsequent action is inevitable: first, the infinitesimal length of conduit immediately adjacent to the reservoir blows down to reservoir pressure; locally the conduit shell contracts to steady-state or normal diameter and the water returns to normal density. In the shrinking process, the water stored in this short length of conduit during passage of the direct wave is emptied upstream to the reservoir. Since the storage process cancelled a positive velocity $+ V$, the emptying process naturally creates a negative velocity $— V$. Similar in action to the direct wave, this reflected negative wave front then proceeds downstream toward the valve with acoustic velocity.

On the basis of physical intuition (which will later be given rigorous mathematical confirmation) we proceed to formulate the very important law of reflection for water-hammer increments at the reservoir: At the reservoir, pressure increments are reflected with opposite algebraic sign and velocity increments with the same algebraic sign.

For a fleeting instant when the reflected negative wave of Figure 1 reaches the completely closed outlet valve, the entire conduit is at normal steady-state diameter, water density and head; but every cross-

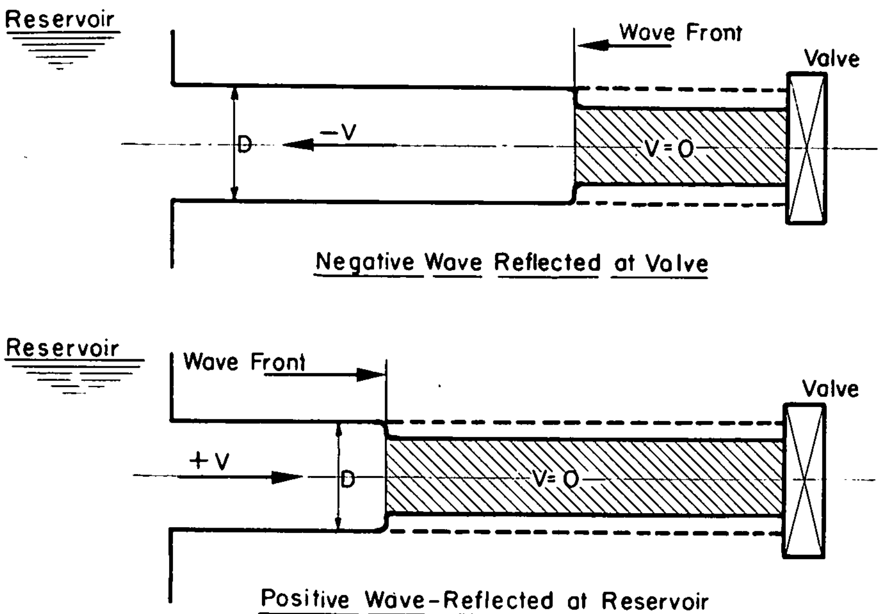


FIG. 2

section of the entire conduit is flowing upstream at velocity — V. The subsequent action is depicted in Figure 2, Negative Wave Reflected at Valve. In view of the inertia of the entire volume of water flowing upstream, it is inevitable that the conduit be sucked below normal head, diameter, and water density, first immediately adjacent to the valve and then progressively upstream at acoustic speed. In this process the conduit velocity is converted to zero behind the wave front.

On the basis of physical intuition (which will later be given rigorous mathematical confirmation), we proceed to formulate the law of reflection for water-hammer increments at the completely closed outlet valve: At the completely closed outlet valve, pressure increments are reflected with the same algebraic sign and velocity increments with opposite algebraic sign.

Finally for a fleeting instant when the negative wave, Figure 2, again reaches the reservoir the entire length of conduit will be at zero velocity, subnormal head, water density and conduit diameter. The inevitable again occurs: the reservoir pressure blows into the conduit first for an infinitesimal length immediately adjacent to the reservoir, restoring the conduit locally to normal diameter, water density and head. The flow of water into the space so provided reestablishes locally the starting velocity + V downstream. The wave front then progresses downstream to the valve with the speed of sound. When the wave reaches the outlet valve the initial steady-state condition has been fully restored. Since conduit friction is assumed equal to zero, the cycle of events depicted by Figures 1 and 2 repeats itself forever without attenuation.

With the foregoing discussion as background we proceed to formulate the basic differential equations for any elementary water-hammer wavelet, produced by any type of valve closure, instantaneous or gradual: (Figure 3):

Applying Newton's law $F = M \dfrac{dV}{dt}$ in the x direction:

$$\frac{\pi D^2}{4}\Big[w(H + \delta H) - wH \Big] = \frac{\pi D^2}{4} \; \frac{w}{g} \delta x \; - \; \frac{\delta V}{\delta t}$$

$$\text{or } -\frac{\delta H}{\delta x} = \frac{1}{g} \; \frac{\delta V}{\delta t} \qquad (1)$$

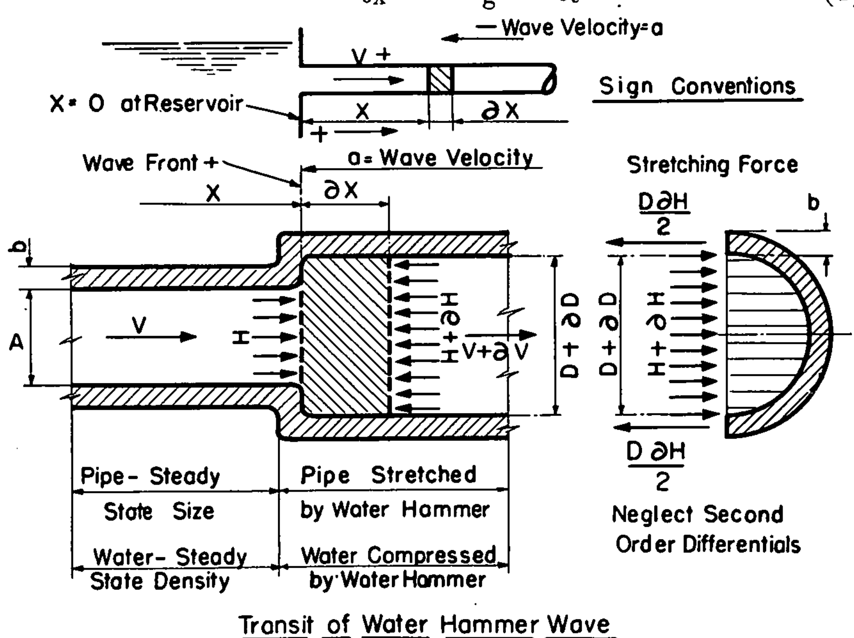


FIG. 3

The volume of water resulting from the extinction of velocity δV, in length δx and in time δt, fills the space made available by stretching the conduit and compressing the water:

$$\frac{\pi D^2}{4}\,\delta V\delta t = -\frac{\pi D^3 W\delta H\delta x}{2bE} - \frac{\pi D^2 W\delta H\delta x}{4K}$$

for convenience let $Q = \dfrac{1}{K} + \dfrac{D}{bE}$

$$\text{Then} -\frac{\delta V}{\delta x} = wQ\frac{\delta H}{\delta t} \tag{2}$$

Combining (1) and (2) we obtain the general differential equations applicable to all cases of water-hammer phenomena, provided conduit friction is assumed equal to zero.

$$\frac{g}{wQ}\,\frac{\delta^2 V}{\delta x^2} = \frac{\delta^2 V}{\delta t^2} \tag{3}$$

$$\frac{g}{wQ}\,\frac{\delta^2 H}{\delta x^2} = \frac{\delta^2 H}{\delta t^2} \tag{4}$$

In Equation (1) replace δx by adt in which a is the velocity of wave propagation:

$$-\delta H = \frac{a}{g}\delta V \text{ and } \delta x = a\delta t$$

Substitute the value of δH, and $\delta x = adt$ in Equation (2) giving the wave velocity

$$a = \sqrt{\frac{g}{wQ}} \tag{5}$$

Unfortunately we are able to solve Equations (3) and (4) only for the case of instantaneous closure of the outlet valve, in which instance H = reservoir head for x = o, and V = o at the outlet valve for x = L, for all values of t,

The resulting solution is:

$$H = H_0 + \frac{aV_0}{g}\sum_{n=1}^{\infty}(-1)^{n+1}\left\{ 1_{t>\frac{(2n-1)L-x}{a}} - 1_{t>\frac{(2n-1)L+x}{a}} \right\} \tag{6}$$

$$V=V_0 \left\{ 1-\sum_{n=1}^{\infty}(-1)^{n+1}\left[{}^{1}_{t>\frac{(2n-1)L-x}{a}} + {}^{1}_{t>\frac{(2n-1)L+x}{a}} \right]\right\} \tag{7}$$

Figure 4 shows the graphs of these equations for the two cases of greatest interest, from which it is immediately apparent that Equations (6) and (7) constitute a rigorous mathematical confirmation of Figures 1 and 2.

By a similar process[1] we are able to include the effect of conduit friction provided that we approximate the true friction head-loss by means of an equivalent expression proportional to the first power of the conduit velocity. This is justifiable because friction head loss is usually of only secondary importance in water-hammer theory. In our subsequent analysis of surge tanks such an assumption would lead to serious error. Figure 5 shows the graphs of the corresponding equations.

Since we cannot solve Equations (3) and (4) for the cases of gradual closure of the outlet valve (which are the cases actually encountered in practical engineering work) we must somehow extend the

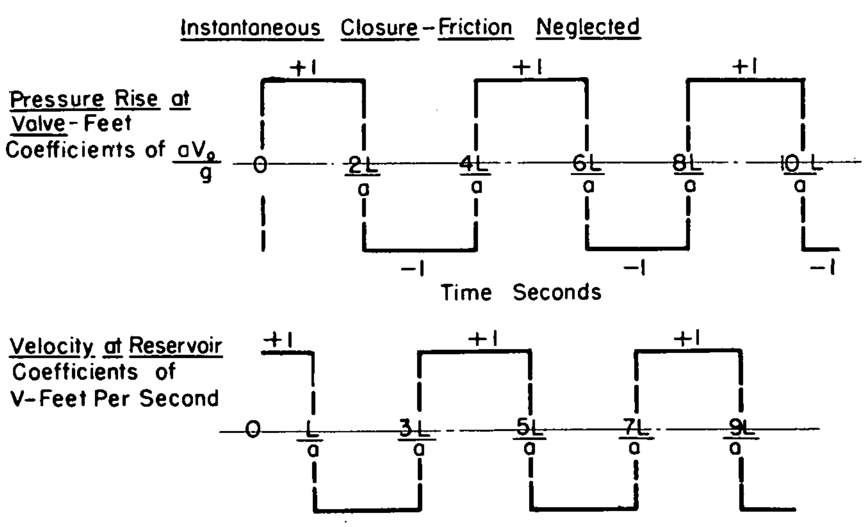


FIG. 4

[1] "Water-Hammer Analysis by the Laplace-Mellin Transformation" by George R. Rich, Transactions ASME 1945—Paper No. 44—A38.

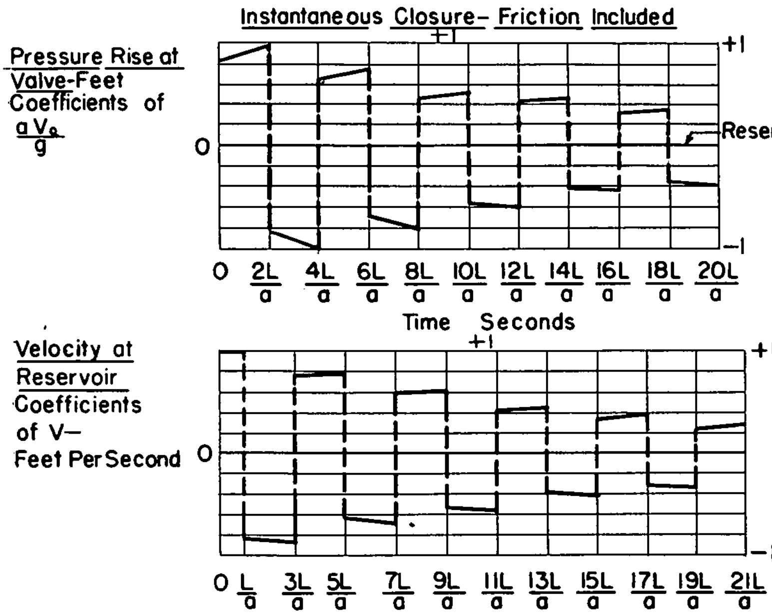


FIG. 5

available solution for instantaneous closure to apply to gradual operation. Accordingly we consider the total time of valve closure to be subdivided into equal intervals of duration $\frac{2L}{a}$ seconds, and we further assume that at the start of each interval the valve is given an instantaneously executed partial movement equal in magnitude to the portion of the closure movement actually executed continuously in that particular interval. By analogy with the case of complete instantaneous closure, each instantaneously executed partial movement generates its own specific procession of square-topped elemental waves, which continue to pass up and down the conduit until attenuated by conduit friction. The net effect or summation of these square-topped elements at any instant is a very close approximation to the effect of actual gradual closure of outlet valve.

Still a second important feature arises in this enforced transition from instantaneous to gradual valve closure: Since the outlet valve is partially open at all stages of the closure, the reflection of negative waves arriving from the reservoir will be only partial; the greater the degree of valve closure, the greater the percentage reflection, and finally reaching 100 per cent reflection when the valve is fully closed. Fortunately for the engineer it is not necessary actually to compute the relative amount of this reflection, since it is established automatically by the fact that the discharge through the valve at any instant must obey the orifice law. The mechanism by which this is effected will be outlined in the next paragraph.

The successive steps in our trial-and-error process of arithmetic integration may be summarized as follows:

(1) Subdivide the total closure time into equal intervals of $\frac{2L}{a}$ seconds.

(2) Assume a trial value of ΔV

(3) Compute $\Delta H = \frac{a\Delta V}{g}$ (Refer to Equation 1)

(4) Compute $\Sigma\Delta H$ of all direct and reflected waves up to the instant in question.

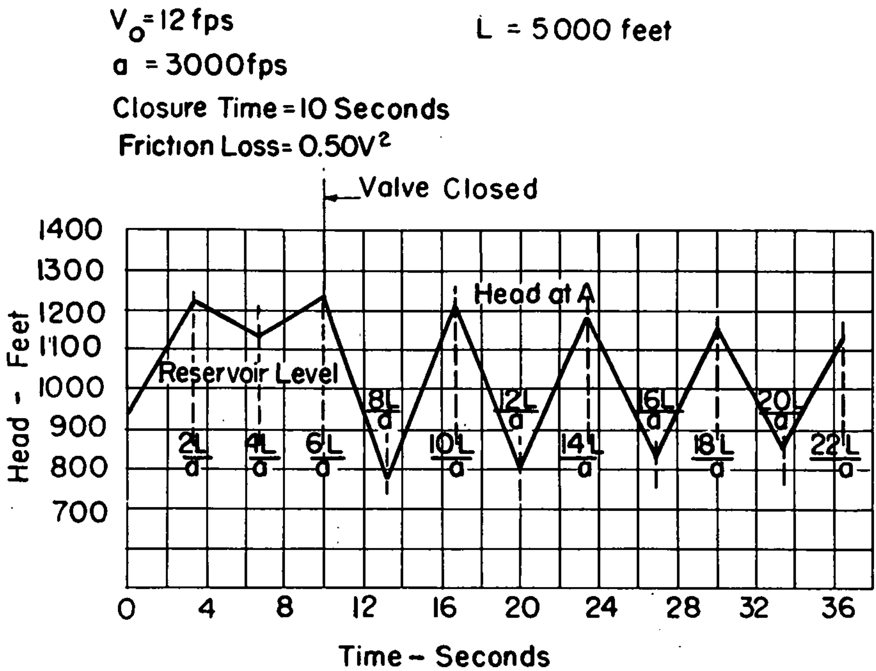
(5) Compute the discharge from the valve by the orifice law $Q = CA_n\sqrt{H_0 + \Sigma\Delta H + F}$ in which F is the friction-head regained. Friction effect is usually neglected.

(6) Q from (5) should agree with V from (2)

Figure 6 is a typical example of gradual closure upon which the reader may practice setting up and carrying out the tabulation for arithmetic integration in the manner best suited to his own individual tastes. For problems in which the outlet valve is being opened instead of closed, the procedure is similar except that the velocity increments ΔV are positive and the corresponding head decrements—ΔH are negative. This can be pictured physically by inverting the cycle of Figures 1 and 2.

In the greater number of problems the terminal outlet mechanism is not a simple valve but a turbo-machine, such as a centrifugal pump or a hydraulic turbine. In such cases the discharge depends upon the instantaneous speed of rotation of the machine, as well as the degree of opening or "setting" of the wicket gates or outlet valve. For this reason it is necessary to have model test curves for the particular machine under consideration, which will give simultaneous values of power, head, speed, gate and discharge or efficiency.

In the corresponding arithmetic integration process we must guess the instantaneous speed of rotation ΔN, as well as the velocity incre-



HEAD-TIME DIAGRAM

FIG. 6

ment ΔV. Consequently we must check out on *two* items instead of just the discharge Q. This is accomplished by incorporating the standard flywheel equation in our tabulation:

Work Done on Generator Rotor = Kinetic Energy Gained

$$\text{Average Horsepower x } 550 \text{ x } \Delta t = \frac{w}{2g}\left[\frac{4\pi^2 R^2(N_1^2 - N_2^2)}{3600}\right] \quad (8)$$

It will be found that checking out on Δt in the above equation involves the least labor.

The conventional problem of this last class is to determine the water-hammer and speed rise of a hydraulic turbine-generator following complete loss of load under short-circuit conditions and for a particular value of WR^2, or rotating inertia of the generator rotor. Figure 7 is calculated for a plant having a relief valve but no surge tank, the

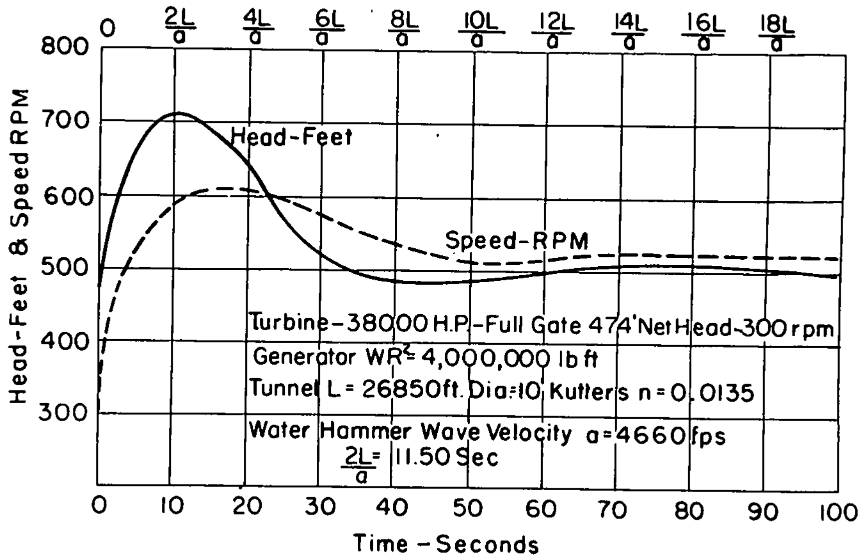


FIG. 7

speed regulation being accomplished by other plants in the system. If the relief valve sticks in opening, the power dashpot connecting rod will stall the closing rate of the turbine gates to the value prescribed for the relief valve. But if the turbine gates stick and fail to close, the increased speed of the turbine operates to reduce the discharge just as effectively as if a valve were closing in the penstock. The curves of Figure 7 show the transient values of head and speed, and the fact that the values damp down to quiescence promptly, indicates the basic stability of the system.

Figure 8 shows the transient pressure drop as the unit of Figure 7 gradually picks up load. The slow opening rate of 150 seconds is deliberately adopted to limit the pressure drop in the penstock. Such a very slow opening rate is permissible in this case because speed regulation is accomplished by other plants in the system.

Since from Equation (5), the wave velocity a, depends upon the physical elements of the conduit, each branch entering a junction point or point of change in conduit size or thickness, will have its own particular value of wave velocity. This naturally gives rise to the generation and propagation of so-called partial reflections at all such junction points. Although a very considerable volume of the current literature

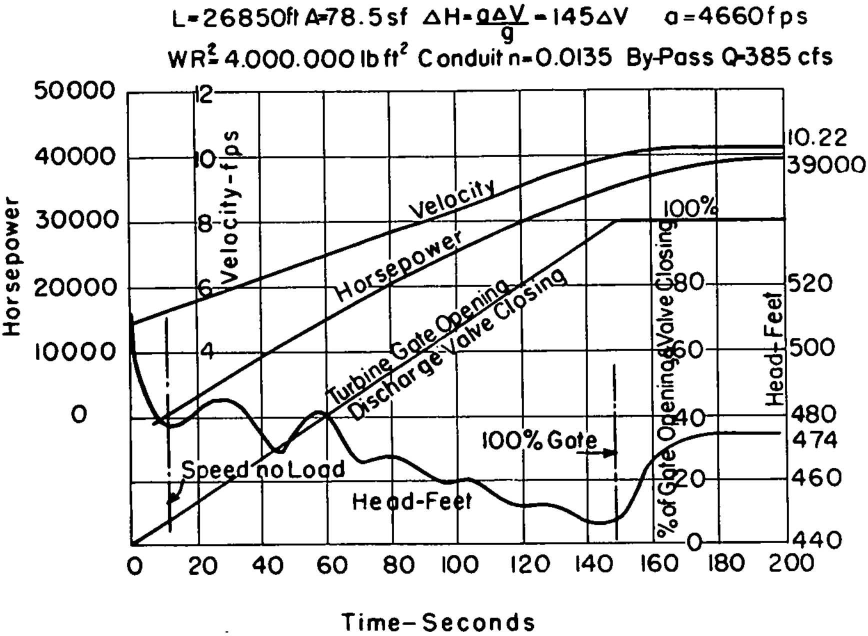


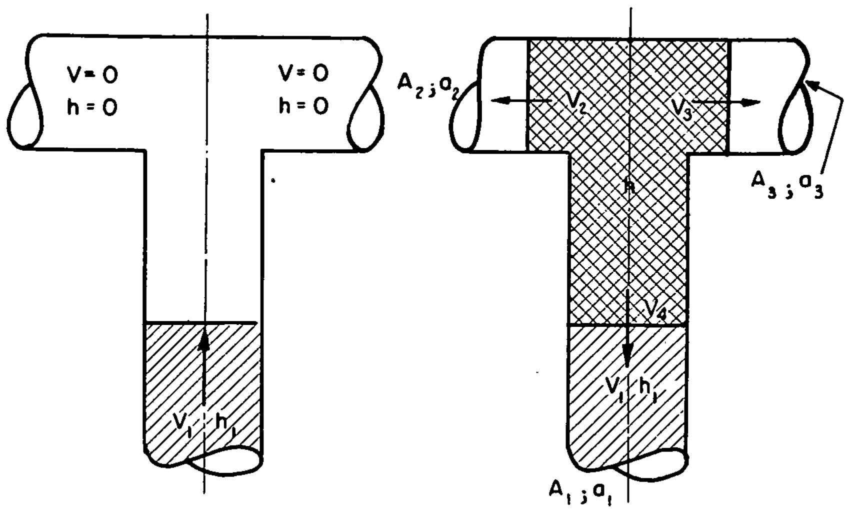
FIG. 8

is devoted to a discussion of the methods of pre-determining so-called reflection coefficients at junction points; the author's own preference is simply to apply Newton's law Fdt = MdV, at each of the wave fronts (Figure 9) and then write the equation of hydraulic continuity for the junction point, since the algebraic sum of the flows entering or leaving the junction must be zero. This reduces the amount of technical lumber to be carried in the memory, and is completely equivalent to the "coefficient" method since the same identical physical laws are used in both cases.

As a rule it is only in very rapid closures that the actual values of partial reflections in compound penstocks become important. For the gradual closures encountered most frequently in practice sufficient accuracy is obtained by employing the weighted average of the wave velocity a and the conduit velocity V over the combined length of conduit L.

With the increasing length of penstocks in hydroelectric installations a point is reached at which either (a) the expense of providing

Partial Reflections at Junction



Before Arrival of Wave After Arrival of Wave

FIG. 9

conduit strength to resist water-hammer or (b) the cost of WR^2 to balance increased time of valve closure, becomes prohibitive. In such cases an artificial reservoir or surge tank is installed as close to the power-station as is economically feasible. The purpose of such a tank is two-fold: first to reduce water-hammer by supplying compensating negative reflections and second, to serve as a source of water-supply upon turbine load-demand while the main conduit is accelerating, or as a water-storage reservoir upon turbine load-rejection while the main conduit is decelerating.

A fundamental difference in the character of the accelerating or decelerating processes in the main conduit above the surge tank, and in the penstock below the surge tank is immediately apparent, Figure 10. The upstream conduit has in effect an open reservoir at each end, and the change in water surface elevation at the tank end is relatively gradual. Hence although the actual mechanism for effecting velocity change is an elastic water-hammer wave motion, the entire length of upper conduit may for all practical purposes be considered as a rigid water-column flowing at any instant under the combined influence of friction and acceleration heads. In other words for the purposes of

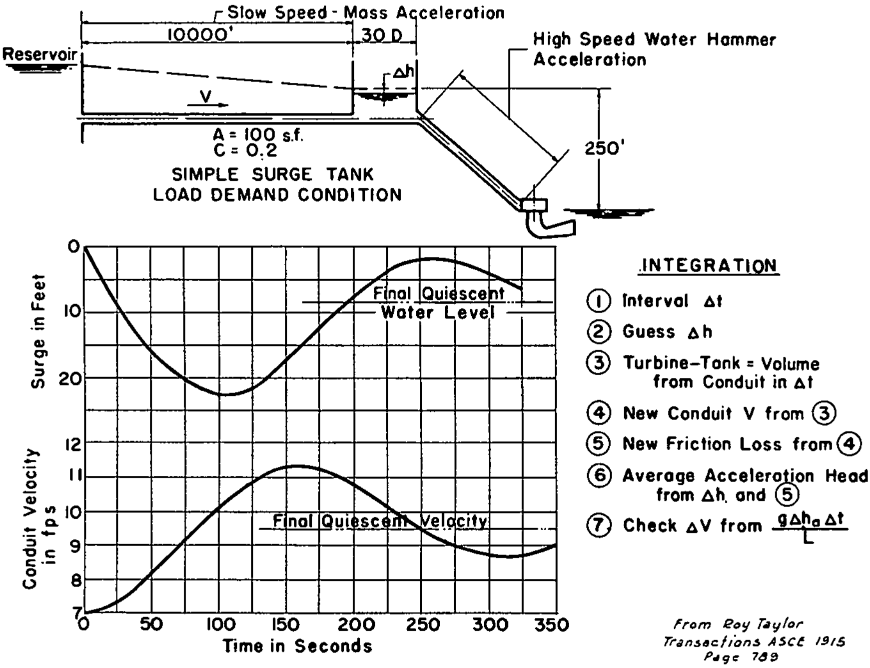


FIG. 10

practical computation the upper conduit may be considered subject to a slow-speed mass acceleration and the penstock to a high-speed water-hammer acceleration, and the two sections treated as completely separate problems.

A first approximation to the size of simple surge tank is obtained by equating the Kinetic energy of the flowing water in the upper conduit to the potential energy of the corresponding volume of water elevated in the surge tank, with a suitable allowance for the effect of conduit friction:[2]

$$\text{The surge } y = \sqrt{\frac{2LV^2}{gA} + F^2} \qquad (9)$$

$$\text{with } F^2 = cV^2$$

[2]"Water Power Engineering" by H. K. Barrows McGraw-Hill-1934-Chapter X "Speed and Pressure Regulation" by W. F. Uhl.

Because of the fundamental impediment to direct solution by means of integrating the differential equations, the accurate verification of surge height for the final design of tank must be performed by arithmetic integration. The steps in the process for the simple tank are summarized as follows:

(1) Select an appropriate interval of time Δt.
On the steep portions of the surge or velocity curve as short a time as 2 seconds may be necessary, while 15 or 20 seconds gives sufficiently accurate results on the flat portions of the curves.

(2) Guess the change Δh in water-surface elevation in the tank at the end of Δt.

(3) From Δh compute the volume flowing in or out of the tank in Δt and also the volume discharged by the turbine in Δt. By simple addition or subtraction these values will give the volume discharged by the main conduit in time Δt.

(4) Knowing the main conduit velocity at the start of Δt and the volume discharged by the conduit in Δt, compute the conduit velocity V at the end of Δt.

(5) Knowing V, compute the conduit friction head-loss at the end of Δt. The instantaneous acceleration head at the end of Δt is obtained by subtracting the friction head-loss from the difference between the water surface elevations in the tank and reservoir.

(6) Compute the average acceleration head for the interval Δt. Then applying Newton's law $Fdt = MdV$ to the entire length of main conduit, compute ΔV for the interval Δt.

$$\Delta V = \frac{g \Delta h_a \Delta t}{L}$$

The corresponding value of V at the end of Δt should check V in Step (4). The trial-and-error process outlined above is continued until the performance curves are completed to the condition of quiescence.

It will be noted from the performance curves, Figure 10,[3] that the action of the simple tank is comparatively sluggish, owing to the fact that the development of accelerating head is inextricably bound

[3]See "Acknowledgment."

up with the water-supply or storage function of the tank. It would obviously be desirable completely to dissociate these two duties so that full accelerating head could be made available early in the quarter-cycle.

This desired separation was accomplished by Mr. R. D. Johnson in the invention of the differential regulator, the physical features of which are shown schematically in Figure 11.[3] Deferring for the mo-

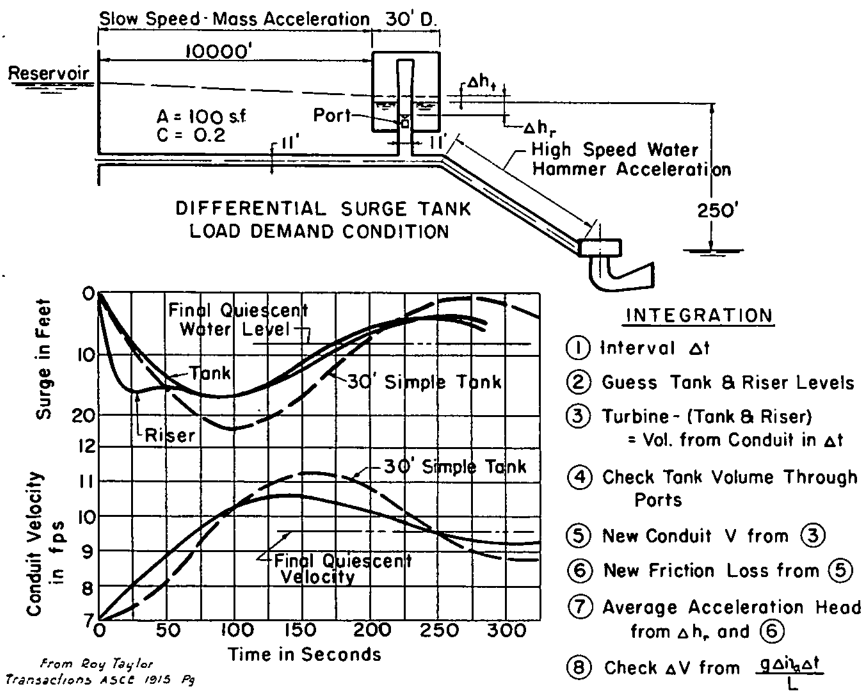
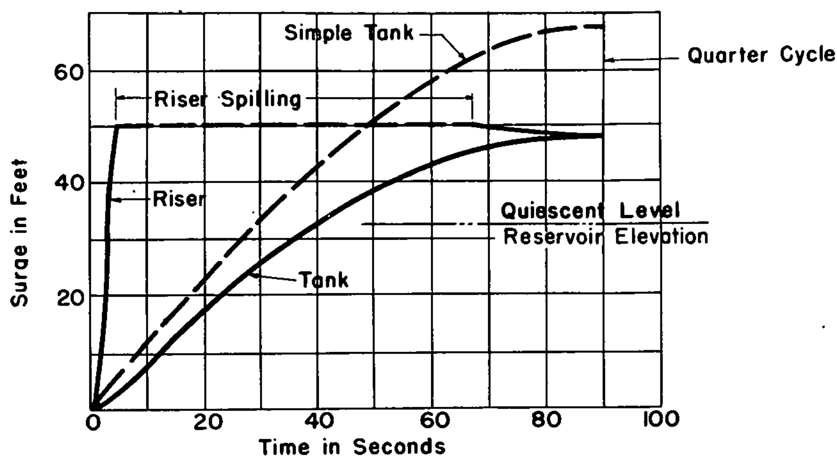


FIG. 11

ment the means for obtaining a preliminary design of physical constituent features for such a tank, we proceed at once to the calculation of surges by arithmetic integration. The mode of thinking is essentially the same as for the simple tank, except that we must guess the elevation of two water surfaces at the end of each time interval: the elevation in the main tank and the elevation in the riser. And since we have made two guesses at the start, we must have two checks at the finish of each trial operation. The second or additional check in this case is that the volume discharged to or from the outer tank in time Δt must follow the orifice law of flow through the riser ports. The relative efficiency of the differential tank over a simple tank of the same diameter is indicated by the performance curves of Figure 11.[3] Figure 12[3] is a typical load rejection curve for the differential



Tank Diameter = 52 feet
Riser Diameter = 12 feet
L = 3220 feet
A = 113 square feet
C = 0.055
V = 24 feet/second

DIFFERENTIAL SURGE TANK
LOAD REJECTION

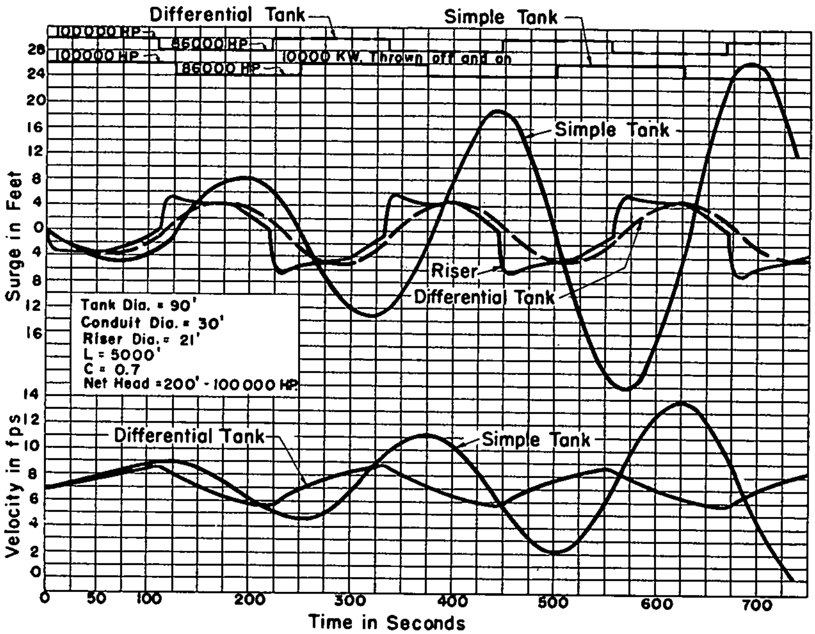
From Roy Taylor
Transactions ASCE 1915 p 800

FIG. 12

tank, and gives a good picture of the promptness with which decelerating head is developed by the rise of water level in the riser pipe.

Figure 13[3] illustrates one of the most striking advantages of the differential regulator, the ability to suppress synchronous load changes having the same natural periodicity as the main conduit. The simple tank of the same diameter is soon caused to overflow while a definite ceiling is established for the surging in the differential tank.

As is readily inferred from Figure 13,[3] it is not enough to construct tanks high enough so that they will never overflow, nor deep enough so that on load demand they will never admit air to the penstock. To insure steady commercial operation, the tank must be large



COMPARISON - SIMPLE AND DIFFERENTIAL SURGE TANKS
10 000 KW. ON AND OFF

From Roy Taylor Transactions ASCE 1915 p 787

FIG. 13

enough in diameter to quench oscillations of the water surface down to quiescence very promptly without sustained pendulation; the tank must have inherent damping power or stability.

To render the pertinent equations tractable to solution we approach the subject of stability by the customary avenue of small oscillations. In the case of the differential tank we argue that for large load changes the velocity through the riser ports produces a very pronounced choking effect, which however, becomes negligible for small load changes. Accordingly we consider the riser and ports entirely removed for the purpose of stability investigation, and may reasonably conclude that if sufficient damping power resides in the outer tank for small load changes, the quenching power will be proportionately improved by the port action in the case of the larger load changes. In the instance of the simple tank or outer tank, the justification for the use of small oscillations, lies in the fact that the beneficial damping power of conduit friction increases as the square of the velocity at the higher load changes.

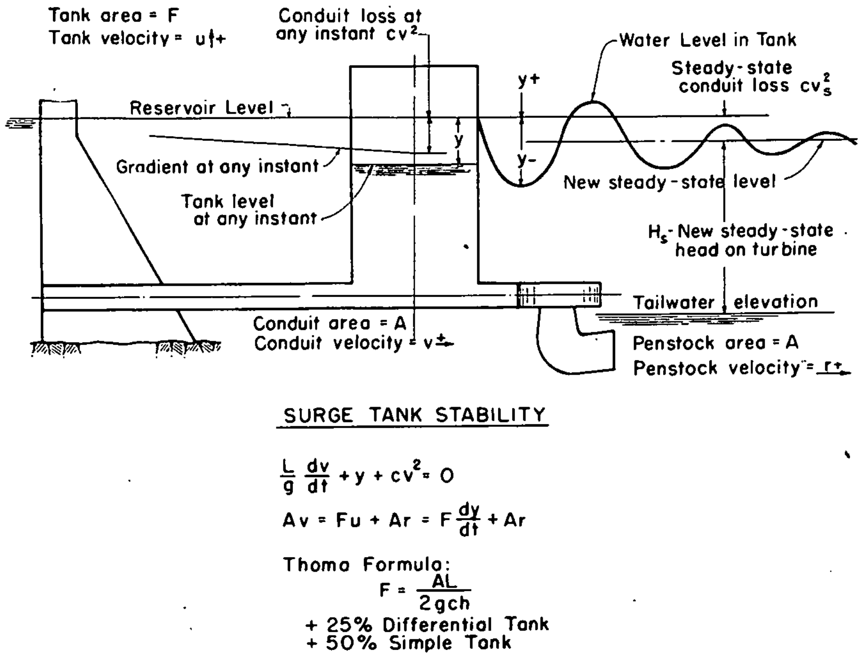


FIG. 14

From Figure 14, the total head comprises the friction head-loss and the acceleration head.

$$\frac{L}{g}\,\frac{dV}{dt} + y + cV^2 = o \tag{10}$$

By hydraulic continuity:

$$AV = Fu + Ar = F\,\frac{dy}{dt} + Ar \tag{11}$$

If the subscript s, denotes the steady-state condition, then the penstock velocity r at any instant

$$r = r_s \left(\frac{H_s}{H_s + cV^2 + y}\right) \tag{12}$$

In this expression we may drop cV^2 for small oscillations; expand the remainder as an infinite series in powers of $\frac{y}{H_s}$ and drop all terms in the higher powers:

$$r = r_s\left(1 - \frac{y}{H_s}\right) \tag{13}$$

Substituting in Equation (11):

$$V = \frac{F}{A}u + r_s\left(1 - \frac{y}{H_s}\right) \tag{14}$$

$$\text{and } cV^2 = c\left(r_s^2 + \frac{2Fr_su}{A} + \frac{2r_s^2y}{H_s}\right)$$

since u^2 and $\left(\frac{r_sy}{H_s}\right)^2$ are very small. With this substitution Equation (10) becomes:

$$\frac{d^2y}{dt^2} - \left(\frac{Ar_s}{FH_s} - \frac{2cr_sg}{L}\right)\frac{dy}{dt} + \left(\frac{gA}{FL} - \frac{2cr_s^2gA}{FLH_s}\right)y + \frac{cgAr_s^2}{FL} = o \tag{15}$$

From the fundamental theory of linear differential equations the character of the solution of Equation (15) is determined by the relative magnitude of the constant coefficients. For a solution that is damped progressively with the time, $\left(\frac{Ar_s}{FH_s} - \frac{2cr_sg}{L}\right)$ must be negative or

$$F = \frac{AL}{2gcH} \tag{16}$$

This is the celebrated Thoma formula which gives the minimum net area of tank that is capable of damping the oscillation to quiescence in a time just short of eternity. Experience shows that in order to secure the rapid rate of quenching required in practical operation, we must add 25 per cent to this Thoma value for the differential tank and 50 per cent for the simple tank.

It is the extreme good fortune of hydraulic engineers that Mr. Johnson's contribution to the science of conduit acceleration did not stop with the conception and invention of the differential regulator. He also provided most incisive charts for quickly obtaining the demand

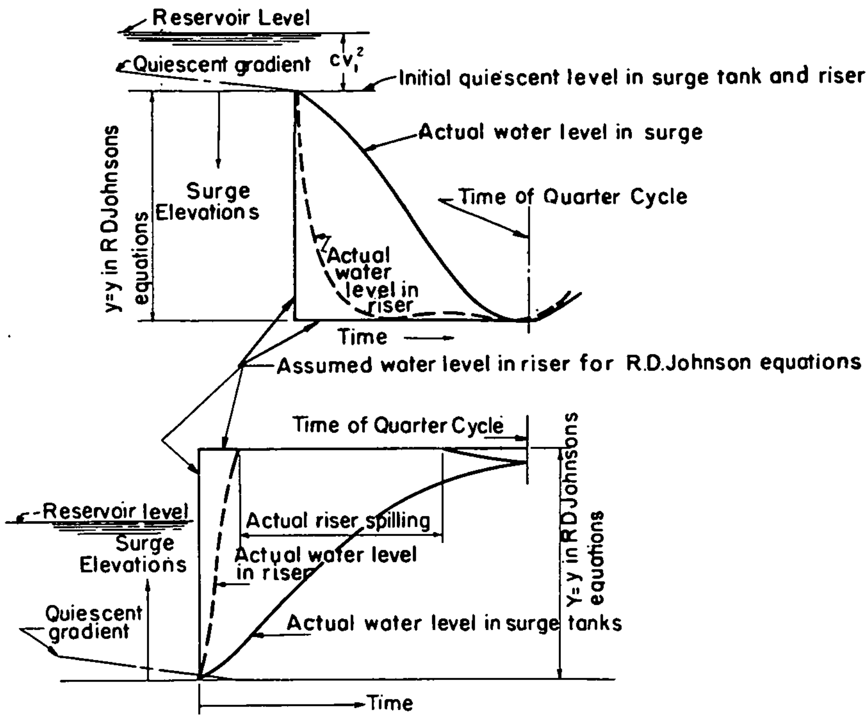


FIG. 15

and rejection surges for any assumed diameter of tank. By employing the reasonable approximations of Figure 15, he rendered the basic differential equations sufficiently tractable for integration, and then summarized the results in dimensionless charts applicable to all cases occurring in practice. So dependable are these charts that the work of arithmetic integration is usually in the nature of just a final confirmation. In the preparation of the charts the port area is not calculated directly, but is assumed to vary in just the right proportion to give the relative relationship of tank and riser levels shown in Figure 15. In actual final design one fixed value of port area is adjusted to meet two requirements. For load demand it must discharge the additional water required by the turbine at the start of the quarter-cycle under the orifice head y; and for rejection it must be small enough so that it will discharge into the outer tank only what remains while the riser continues to spill over the top until the quarter-cycle. For large assumed values of load demand this may require diverging ports which have a greater discharge coefficient for demand than under reversed flow for rejection.

As would naturally be inferred, the actual diameter of tank provided in excess of the minimum required for stability by the Thoma formula, is a matter of economic design to fit the local terrain. It may be cheaper to furnish a larger diameter tank with small surge range, all elements of the economic picture being duly considered.

Figure 16 is an actual full-scale test of the Appalachia differential

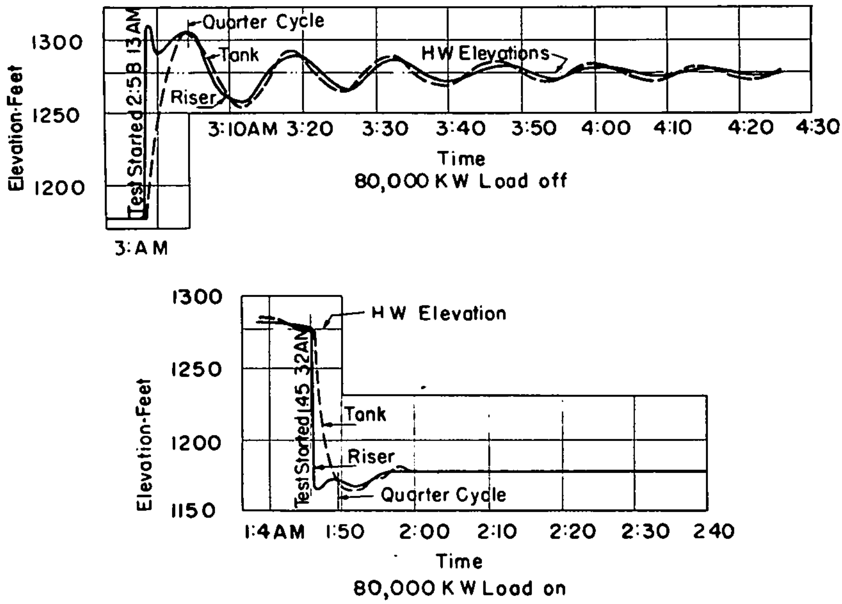
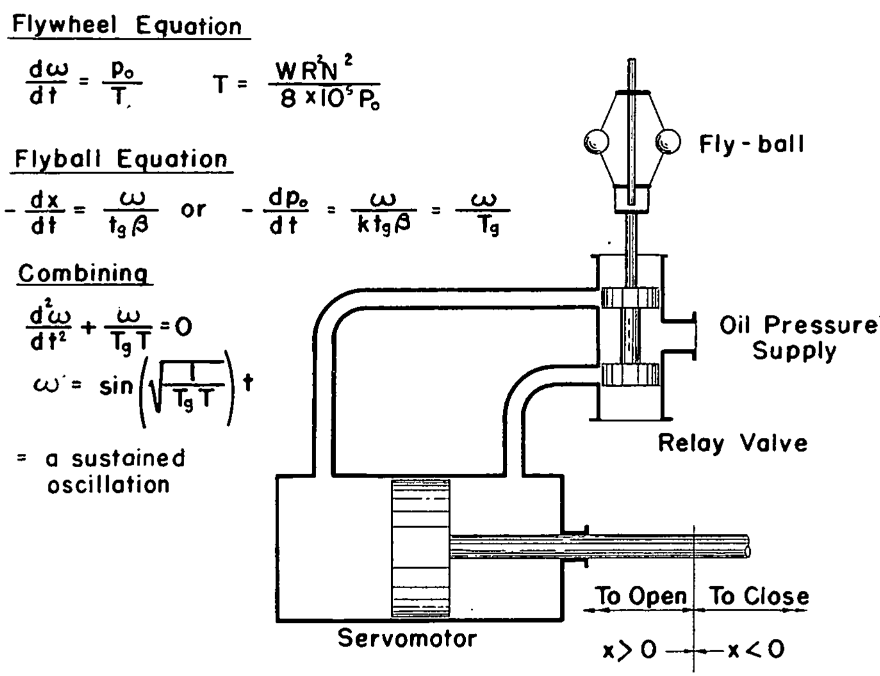


FIG. 16

surge tank of the Tennessee Valley Authority.[3] The tank is 66 feet in diameter and 250 feet in height, excavated in solid rock from the bluff directly behind the power-station. The performance curves depart slightly from the ideal relationship during the quarter-cycle because the reservoir elevation at the time of test was not at the more adverse levels specified for design. However, the performance curves are of interest in showing the duration and character of the action in a very large tank under exceptionally severe load changes.

As the final coordinate topic in our attempt at correlation let us give consideration to the subject of stability or quenching power in the governor and its auxiliaries, first laying the ground work with the assistance of Figure 17. It is apparent intuitionally after a little study that the crude mechanism therein depicted would continually over-travel beyond the proper quiescent limit corresponding to the new load, and that such a device could never catch up with its intended work. That such is the case is confirmed mathematically.



SPEED RESPONSIVE GOVERNOR - NO COMPENSATION

FIG. 17

The notation is:

$$\omega = \frac{N - N_0}{N_0} \text{ the relative speed change}$$

$$p_0 = \frac{P - P_0}{P_0} \text{ the relative power change}$$

T = the specific inertia of the rotating parts $\frac{WR^2N^2}{16.2 \times 10^5 P_0}$

x = the relative servomotor travel or gate change $= \frac{X - X_0}{X_0}$

t_g = the time required to move the turbine gates to the new load position.

β = a constant measured in terms of ω, showing at what relative speed change the servomotor piston speed reaches its full value. This depends upon the inertia of the mechanism, and of the oil in the servomotor piping system.

k = the ratio $\frac{dx}{dp}$ from the power-gate curve of the turbine.

The familiar flywheel equation in differential form is:

$$\frac{d\omega}{dt} = \frac{p_0}{T} \tag{17}$$

The flyball equation simply states that the servomotor piston speed depends directly upon the magnitude of the relative speed change ω, and inversely upon k, β and t_g:

$$-\frac{dx}{dt} = \frac{\omega}{t_g\beta} \text{ or } -\frac{dp_0}{dt} = \frac{\omega}{k\beta t_g} = \frac{\omega}{T_g} \tag{18}$$

Combining Equation (17) and (18) we obtain

$$\frac{d^2\omega}{dt^2} + \frac{\omega}{T_g T} = 0 \qquad \omega = \sin\left(\sqrt{\frac{1}{T_g T}}\right)t \tag{19}$$

which is the equation of a perpetually sustained oscillation.

By giving similar study to the rudimentary mechanism of Figure 18, it is evident intuitionally that the insertion of the linkage connection known as the primary compensation, serves as a means of anticipating where the final quiescent position of the servomotor piston should be and thus bringing the mechanism to quiescence at the correct point.

It can be seen from Figure 18 that if the flyballs drop below the synchronous speed level in response to a load demand of 100 per cent,

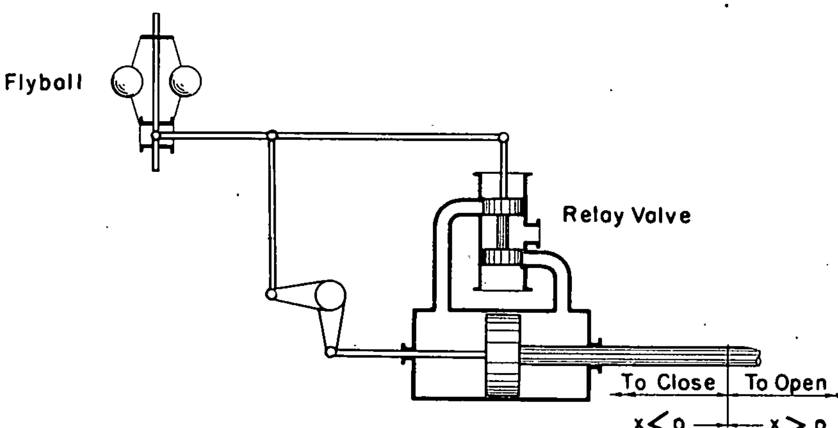
$\frac{d\omega}{dt} = \frac{P_o}{T}$ Flywheel Equation $-\frac{dp_o}{dt} = \frac{1}{T_g}(\omega + \delta p_o)$ Flyball Equation

δ = Speed droop

Combining

$$\frac{d^2\omega}{dt^2} + \frac{\delta}{T_g}\frac{d\omega}{dt} + \frac{\omega}{TT} = 0$$

For a damped aperiodic $= \delta 2\sqrt{\frac{T_g}{T}}$



Speed Responsive Governor
With Primary Compensation

FIG. 18

the linkage operates to restore the relay valve a certain definite portion of its back-travel, as the servomotor piston moves to the right. This means that when the relay valve does finally become recentered the flyballs are below synchronous speed level by the amount already accomplished by the primary compensation. Thus the speed at full-gate is less than that at speed no-load by a percentage aptly termed the "speed droop". Its manifest benefit is readily confirmed mathematically. The servomotor piston speed now depends not on ω alone, but also upon the restoration effected by the primary compensation accompanying the servomotor piston travel or gate movement.

The flyball equation then becomes:

$$-\frac{dp_0}{dt} = \frac{1}{T_g}\left(\omega + \delta p_0\right) = \text{Flyball Equation} \qquad (20)$$

And the combined equation is:

$$\frac{d^2\omega}{dt^2} + \frac{\delta}{T_g}\frac{d\omega}{dt} + \frac{\omega}{T_g T} = 0 \qquad (21)$$

Again from the standard theory of linear differential equations with constant coefficients it is necessary that for a damped aperiodic or "dead-beat" value of the speed change ω the speed-droop

$$\delta > 2\sqrt{\frac{T_g}{T}} \qquad (22)$$

It is evident from our previous discussion of the action of speed-droop that δ must in practical operation be of small magnitude (less than 5%) to avoid cancelling the sensitivity of the flyball. If δ is very large we might have stability but very inferior speed control.

But to keep δ small, either the fly-wheel inertia T must be very large, or the response T_g of the governor very fast, which would increase water-hammer. Both of these results would cause prohibitive expense. The practical solution is to accept a rapidly quenched or damped periodic action instead of the theoretically perfect "dead beat" type.

This damped periodic action may be suitably accomplished in either of two ways: first, we may incorporate an acceleration-responsive element in the governor head to accompany the speed-responsive fly-ball; or second, by means of a suitable dashpot, we may arrange to supply a very large value of speed-droop for a very short time at the start of the servomotor piston travel, and diminish the speed-droop to zero as the piston stroke nears completion. This so-called secondary compensation has the same benefit physically and mathematically as the incorporation of an accelerometer in the flyball head. The mathematical confirmation follows the same method of approach previously employed.

The effect of water-hammer is naturally to aggravate the difficulty of speed regulation since it acts directly to increase the energy supplied to the turbine. The eminent French engineer, Mr. Daniel Gaden has made an exhaustive analysis of this water-hammer effect, giving consideration to the relative natural frequencies of the governor mechanism and the pressure pulsation in the penstock. His final results are embodied in the equation:

$$T_\theta T > K \left(\frac{3}{2}\theta\right)^2 \qquad \text{— Gaden Formula} \qquad (23)$$

$$\theta = \frac{LV_0}{gH_0} \qquad \text{— Penstock Characteristic}$$

This simple expression may be used to check governing system stability with the same ease with which we employ the Thoma formula in verifying surge tank stability. The proper value of the constant K depends simply upon the steady-state head in accordance with the following tabulation:

H-feet	30	150	300	500	1000
K	1.31	1.36	1.41	1.84	2.76

In contrast with the Thoma formula, however, Mr. Gaden has incorporated an allowance to insure the commercially acceptable rate of damping in his derivation. Because this liberal value of logarithmic decrement has been so provided, no additional percentage allowances need be made when using the Gaden Test in practice.

Acknowledgment

The author is indebted to the American Society of Civil Engineers for permission to reproduce Figures 10, 11, 12 and 13 from Roy Taylor's excellent discussion of R. D. Johnson's classic paper "The Differential Surge Tank", from Transactions ASCE, Vol. LXXVIII, 1915, Paper No. 1324; to the American Society of Mechanical Engineers for permission to reproduce Figures 4 and 5 from "Water-Hammer Analysis by the Laplace-Mellin Transformation" by George R. Rich, Transactions ASME, 1945, Paper No. 44-A38; to the Tennessee Valley Authority for permission to reproduce Figure 16 showing the prototype performance of the Appalachia Surge Tank; and to Mr. Daniel Gaden, Directeur, Ateliers des Charmilles, Geneva, Switzerland, for kind assistance in connection with the subject of governing stability.

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BOD LOADINGS IN ACTIVATED SLUDGE PLANTS

WM. E. STANLEY, MEMBER* AND J. F. BERBERICH†

(Presented at a meeting of the Sanitary Section of the Boston Society of Civil Engineers, held on December 3, 1947.)

INTRODUCTION

This paper comprises a preliminary summary of an investigation of BOD Loadings based on operating data from a selected number of activated sludge plants, relative to the interrelation of several major factors influential to effective plant operation. The inquiry is an initial effort toward developing empirically a reasonably logical procedure for the design of activated sludge plants on the basis of the BOD in the applied sewage.

Many basic operating data were collected and a preliminary analytical procedure developed by the junior author in a thesis study, as part of the requirements for the degree of Master of Science in Sanitary Engineering (awarded June 13, 1947) at Massachusetts Institute of Technology. These data have been extended, recomputed and replotted by the senior author.

These analytical discussions and graphical results are presented, as an introductory phase of an attack on a complicated problem which will require the cooperation of both plant operators and plant designers before any reasonably satisfactory solution might be found.

Operating data were obtained through the courtesy and assistance of plant operators of 27 plants in 23 cities as listed in Table I. Data supplemental to the routine operating reports have been furnished through correspondence.

The BOD test is presently the best available index of effective sewage treatment plant operation, where removal of organic pollution is of major importance. Recent studies[1] indicate that the results of the present standard laboratory procedure for the BOD test, as a measure of the unoxidized organic matter in the final effluent, may be affected by the status of nitrification of the nitrogenous matter in sewage. If nitrification has started and is continued in the BOD

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TABLE I

LIST OF PLANTS, COÖPERATING OFFICIALS AND RECORDS OF AVAILABLE DATA

Plant	Cooperating Official	Record of Operating Data Dates	Length of Record	Symbol letter (See charts)
Ann Arbor, Mich.	C. Preston Witcher, Superintendent	1944-46 Oct. '45-) June '46)	2½ yrs. 8 months	a a′ (Plain Aeration)
Austin, Texas	A. H. Ullrich, Supt., Water & Sewage Treatment	1944 1945	1 year 1 year	b b_1
Baltimore, Md.	John J. Hunt, Sewerage Engr.	1945	1 year	c
Chicago San. Dist., Chicago, Ill.	Dr. F. W. Mohlman, Director of Laboratories,			
	a) South West plant	1943 1946	1 year 1 year	d d_1
	b) North Side Plant	1943 1946	1 year 1 year	e e_1
	c) Calumet Plant	1943 1946	1 year 1 year	f f_1
Cleveland, Ohio (Easterly Plant)	J. W. Ellms, Commissr. of Sewage Disposal	1940-45	6 years	g
Decatur, Ill.	Dr. W. T. Hatfield, Supt. San. District of Decatur	1946	11 months	h
Fort Wayne, Ind.	Paul L. Brunner, Chief Chemist	1941-46	5 years	i
Gary, Ind.	W. W. Mathews, Superintendent	1941-45	5 years	j
Hagerstown, Md.	C. W. Stump, City Engr.	1943-46	4 years (7 mo. in ea.)	l
Hammond, Ind.	Carl B. Carpenter Supt. San. Dist. of Hammond	1942-46	5 years	m
Jackson, Mich.	A. B. Cameron, Superintendent	1942-46	5 years	n
Madison, Wis.	H. O. Lord, Ch. Engr. Madison Metro. Dist.	1947	1 year	p
Marion, Ind.	David Backmeyer, Superintendent	1942-46	76 months	q
Marshalltown, Iowa	L. F. Skorczerki, Superintendent	1943-46	3 years	r

TABLE I (continued)

Plant	Cooperating Official	Record of Operating Data: Dates	Length of Record	Symbol letter (See charts)
Milwaukee, Wis.	James L. Ferebee, Ch. Engr. Metro. Dist.			
	a) West Plant	1945	1 year	s
	b) East Plant (New)	1945	1 year	t
Pasadena, Cal.	Wm. A. Allen, Adm. Asst. to City Mgr.	1945-46	1 year	v
Peoria, Ill.	L. S. Kraus, Chief Chem.,	1946	1 year	w_1
	Peoria San. Distr.	1942-46	5 years	w
Pontiac, Mich.	Thomas J. Doyle, Superintendent	1946	1 year	x
	Floyd Vermette, Chemist			
Richmond, Ind.	W. E. Ross, Supt.	1945	1 year	z_1
		1946	1 year	z
San Antonio, Texas	E. J. M. Berg, Office of Park Comm.	1946	1 year	aa
Springfield, Illinois	C. C. Larson, Chemist Springfield San. Dist.	1942	1 year	bb
Syracuse, N. Y.	Uhl T. Mann, Chief Operator, Onondaga Pub. Wks. Comm.	Jan.-June 1947	6 months	cc
Two Rivers, Wis.	Erwin A. Bartz, Supt.			
	a) East Plant	1946	1 year	dd_1
	b) West Plant	1946	1 year	dd_2
	Average both	1946	1 year	dd

bottles, larger values of residual BOD may result, which would indicate an apparent lower percentage removal of BOD. The effect of nitrification will be discussed later in this paper.

However, modifications in the laboratory determination of the effluent BOD figures would account for only a small part of the wide variations in the results obtained at the various plants, as graphically illustrated in the several charts hereinafter described.

Influential Factors

Major factors influential to the effective operation of the activated sludge process comprise:

(1) The Organic Loading on the process—represented by the BOD (5 dy) applied to the aeration (and reaeration) units. The loading unit as used herein is pounds of BOD applied per 1000 cubic feet of aeration tank volume (any volume for sludge reaeration being included). This represents the pollutional material to be reduced by the biochemical reactions which take place in the aeration (and reaeration) tanks.

(2) The Aeration Contact Period, in hours—the time the sewage is in contact with activated sludge and air—i.e. the time period in which the organic constituents of the sewage may be absorbed by the active sludge.

(3) The Sludge Solids Concentration in the aeration tanks—an index to the quantity of active sludge, generally reported as ppm of solids in the mixed liquor—the concentration of solids in the returned activated sludge affects the aeration contact period or the concentration of sludge solids in the mixed liquor or both.

(4) The Amount of Air Required to properly supply oxygen and to provide sufficient agitation—i.e. the air serves a dual function. The amount of air depends on a number of operation factors. It is quite generally reported as total volume of free air in cubic feet and as cubic feet of free air per gallon of sewage.

(5) The Character of Activated Sludge—particularly its concentration, oxidation activity (or capacity), and the degree of nitrification.

These several major factors are interrelated; in some cases the interrelation is quite complex. The character of the organic load is quite likely a factor not yet fully understood.

Design Bases

Bases of design upon simple relationships, such as detention periods in hours, pounds per day of BOD per 1000 cubic feet of aeration tank volume, or pounds of BOD per day per 1000 cubic feet of air, have been used, but have not proven entirely satisfactory.

It appears likely that a more complex measurement unit or parameter would indicate more satisfactorily the proper basic capacities for design.

Many diffused air type activated sludge plants have been designed on the basis of an arbitrary aeration tank volume sufficient to provide about four to six hours' detention of a mixed liquor flow, computed as the average sewage flow plus 20 to 25 per cent returned activated sludge, with air blower and piping capacity for an arbitrary amount of air—possibly a maximum of 2.0 cubic feet per gallon of sewage. Mechanical aeration plants have usually been provided with longer detention periods based on the average sewage flow, but with a smaller percentage of returned activated sludge.

The design of trickling filters on the basis of applied BOD loadings in terms of pounds per unit volume of media has become relatively general practice. So in recent years, consideration has been given to the use of BOD data as the basis of design for activated sludge plants.

Greeley[2] has suggested that, for average domestic sewage, a reasonable design practice might provide for a BOD (5 dy) loading of 25 to 30 pounds per 1000 cubic feet of aeration tank volume with 1 to 2 pounds applied BOD per 1000 cubic feet of air supplied and suspended solids in the mixed liquor ranging from 1500 to 2000 ppm.

The National Research Council report[3] on military sewage treatment plants proposed a loading parameter, including pounds BOD per day per 1000 pounds of suspended solids per hour of aeration, and states—"This method of rating loading reflects both the amount of biologically active material and the effective time for biological reaction." Curves were included in the report for military and municipal plants.

Kraus has reported[4] on a procedure for increasing the concentration of the sludge solids in the mixed liquor by using digester sludge and ample reaeration. He has also made several studies of aeration tank operation for various BOD loadings, unpublished results of which have been made available by letter and have been included in this study.

Mann has reported[5] several studies of BOD loadings at the Syracuse Ley Creek plant, and has attempted to determine certain interrelationships between the various factors.

Hatfield, at Decatur, Illinois, has been studying BOD loadings.

Some of his (unpublished) ideas and conclusions have been considered in this study.

Measurement Units

This study was related to the aeration and final tanks only. So throughout this discussion the loadings refer to the BOD of the primary tank effluent applied to the aeration units and the BOD removals refer to the removals through the aeration and final tanks.

It seems well to explain the computation procedure selected for certain measurement units, namely, (1) BOD loadings, (2) aeration contact period, (3) air supply and (4) operating results accomplished.

BOD loadings have been computed as pounds of BOD (5 dy) applied per day per 1000 cubic feet of aeration tank volume. The volume of tank for this purpose has been taken as the total volume of aeration tanks, irrespective of whether a part of the total tank volume is used for reaeration.

This assumes that the operator will adjust the use of aeration tank volume as between direct aeration of mixed liquor or reaeration of sludge as he finds desirable for optimum economy, which has been routine practice at Decatur, Peoria, Austin (Tex.), San Antonio, and elsewhere. Many operators do not use sludge reaeration.

The Aeration Contact Periods, in hours, have been computed on the basis of the flow of mixed liquor through that portion of the aeration tanks used for sewage or mixed liquor aeration, which basis of computing aeration hours seems to have been used by most of the plant operators. Mohlman has suggested that the designer should use aeration hours determined by the total aeration tank volume divided by the flow of settled sewage, leaving to the operator the decision as to the percentage of return sludge to use.

Air supply, in terms of cubic feet of free air per gallon of sewage, is included in most operation reports and has been quite generally used to date by plant designers and operators alike to indicate the relative magnitude of air usage. Since the unit of cubic feet per gallon of sewage has been so commonly used it has been included in this study as the air measurement unit.

However, there appears to be no basic relation between sewage flows and air quantities. A more basic measurement unit might be either cubic feet of air per pound of BOD applied, or removed, or possibly cubic feet of air per 1000 cubic feet of aeration tank volume. However, air quantities in certain plants are not closely controlled, the amount of air frequently depends more on the blower unit capacities than on air requirements for oxidation. Also the reported quantities may include the air used for sludge air-lifts and sewage conduit aeration. Further, the air quantities are much larger than the amount required to supply the oxygen demanded. Methods for a more economical use of air are being considered by various investigators.

Results of operation have been stated in terms of (1) ppm BOD (5 dy) removed and (2) percentage removal of BOD for the purpose of comparing the performance of several plants. A third possible measurement unit—i.e. ppm BOD residual in the plant effluent—was used in the earlier thesis computations, but has not been included herein.

Analysis of Operating Data

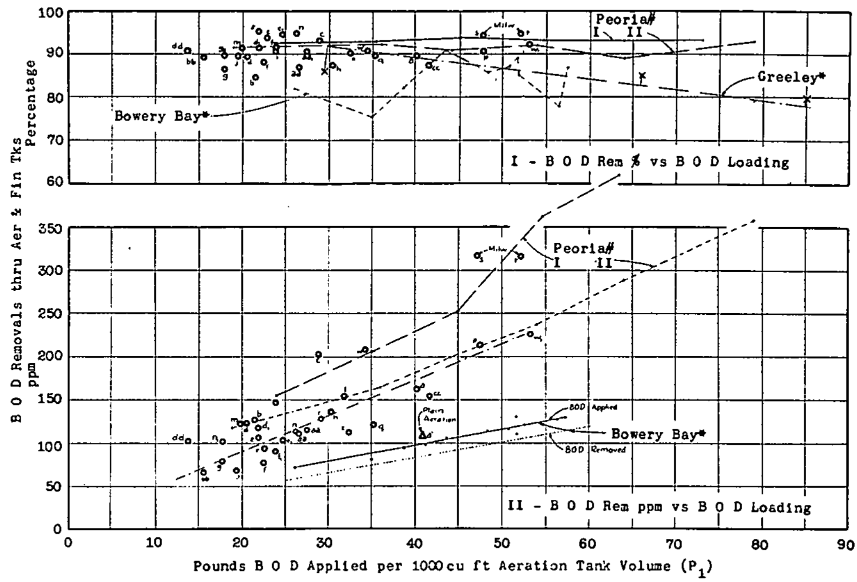
Certain pertinent items of operating data, abstracted from routine and special operation reports, have been tabulated and from these a number of measurement units have been computed. The results from various plants are presented graphically in Figures I to VIII inclusively, the plotted points being keyed to the several plants by lower case letters as shown in Table I.

The discussion of the analytical procedure will be included under the following subdivisions:

1. Aeration Tank Capacities related to BOD.
2. Aeration Contact Periods.
3. Sludge Solids Concentration in Aeration Tank.
4. Air Supply Quantities.
5. Character of Activated Sludge.
6. Effect of Nitrification.
7. More Complex Parameters.

Aeration Tank Capacities Related to BOD Loadings

BOD (5 dy) quantities in the primary settling tank effluent related to aeration tank volumes, i.e. BOD applied in pounds per 1000 cubic feet of aeration tank volume, are shown graphically by Figure I with BOD loadings plotted against BOD removals in ppm and in per cent.



Ref:
* SWJ 15, p.1069, Nov.1943
\# Special Tests by Kraus (ltr)

Fig. I - B O D Removals vs B O D Applied lbs per 1000 cu ft Aeration Tank

These data (from 27 plants) show a 90 to 95 per cent removal of BOD, through aeration and final tanks, for BOD loadings ranging from about 15 to more than 53 pounds of BOD applied per day per 1000 cubic feet of aeration tank volume.

Results of special experimental studies at Peoria (plotted in Figure I) indicate no falling off in percentage removal of BOD with loadings as high as 80 pounds per 1000 cubic feet of aeration tank, including a substantial volume used for sludge reaeration. Hatfield, at Decatur, Illinois, reports (by letter) that with substantial sludge reaeration he has had BOD loadings up to 74.5 pounds per 1000 cubic feet of aeration tank, including the reaeration volume, with no sludge bulking.

Data published by Greeley,[6] (plotted in Figure I as lines "Greeley" and "Bowery Bay") from experimental studies at Chicago and New York, show a falling off in percentage BOD removals for loadings greater than 30 pounds per 1000 cubic feet of aeration tank. However, the sewages were much weaker at Chicago and New York than at Peoria and Decatur; also no reaeration of sludge was included.

The two curves for Peoria (studies I and II) and the Bowery Bay curve, in Part II of Figure I, are so far apart it seems obvious that other factors are involved.

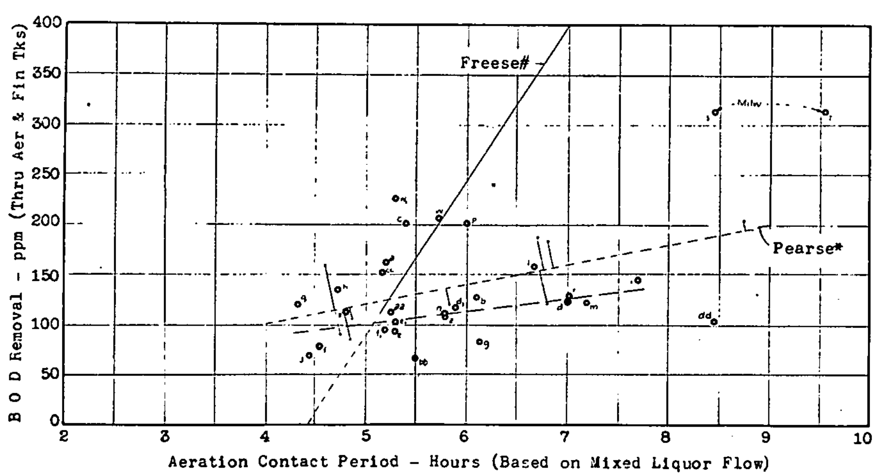
The two points "w" and "w_1" representing Peoria operation results for 1942-46 (5-year average) and 1946 (1-year average), respectively, indicate the same variation as the studies I and II curves. The data from Peoria show that the only significant difference for these two points "w" and "w_1" was in the amount of returned sludge and the amount of aeration tank volume used for sludge reaeration.

The returned sludge at Peoria averaged 29.5% of the sewage flow, during 1946 (point "w_1"), while the returned sludge averaged 37.8% of the sewage flow during 1942-46 (point "w"). (During 1945 the returned sludge averaged 46.8% of the sewage flow.)

The Bowery Bay sludge solids in the mixed liquor were low and also the hours of aeration contact were shorter than for most of the plants included in this study.

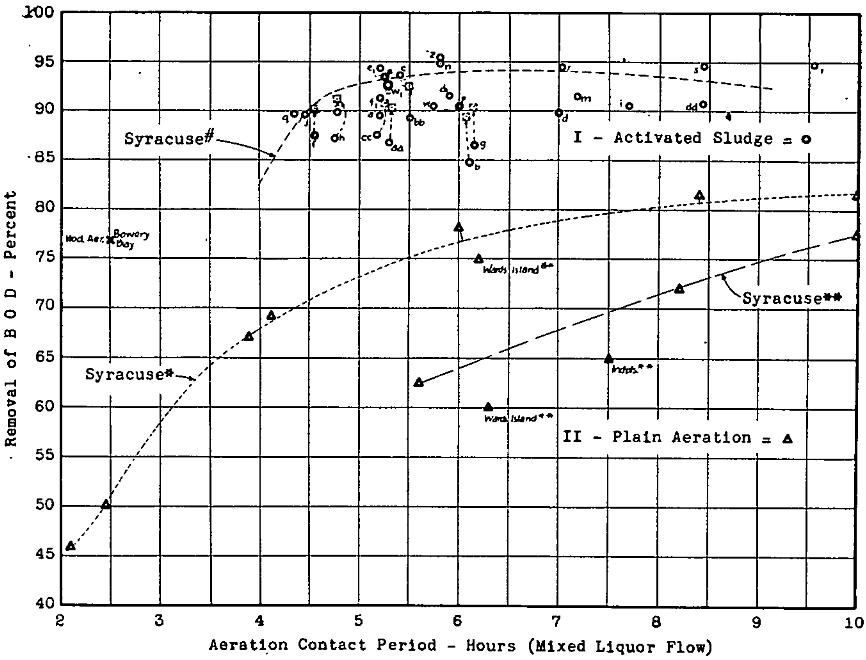
Aeration Contact Periods

Aeration contact periods (hours) are graphically compared to BOD removals in ppm by Figure II and in per cent of the applied BOD by Figure III.



Ref:
* Pearse & APHA Comm, SWJ 14, p.16, Jan.1942
\# Freese, Trans.ASCE 103, p.1624 (1938)

Fig. II - Relation of ppm B O D Removal and Aeration Contact Period



Ref:
Sew Wks Eng 16, p 514, Oct 1945
* SWJ 18, p 465, May 1946
** Reported by L. R. Setter, SWJ 18, p 472, May 1946

Fig. III - Relation of Percent B O D Removal and Aeration Contact Period

Two previously published curves have been plotted also in Figure II. The "Freese" line, published in 1938,[7] based on limited data, does not agree with the presently recorded more extensive operating data. The "Pearse" line proposed in 1942 by the A. P. H. A. Committee on Sewage Treatment—Mr. Langdon Pearse, Chairman[8]—comes closer to fitting the presently reported operating data.

However, the plotted points, for the several presently recorded operating data, and also the data considered by the A. P. H. A. Committee, are so widely scattered it seems evident that other factors are involved. So it is not feasible to determine the relationship of BOD removals, in ppm, and the aeration period, in hours, by a simple plotting of these two factors.

Figure III, showing the percentage removal of BOD plotted against hours of aeration contact, gives some hint as to the effect of other factors. There appears to be a reduction in the percentage of removal for aeration contact periods less than 4.0 hours and longer than 7 or 8 hours. The certainty of this observation is obscured somewhat by the difference in mixed liquor concentration, which factor also affects the results.

The results of plain aeration, particularly the data published by Mann[5] and Setter,[9] show a definite increase in percentage removal with longer aeration contact periods up to 8 hours. The rate of increase appears to be small after 7 or 8 hours. For a given aeration contact period the percentage removal is greatest for the plants using larger quantities of suspended solids in the aeration tanks (i.e. greater mixed liquor concentration).

Sludge Solids Concentration in Aeration Tank

The effect of the suspended sludge solids concentration in the mixed liquor has been discussed in various papers on activated sludge. The operating results of this study are shown in Figure IV where the

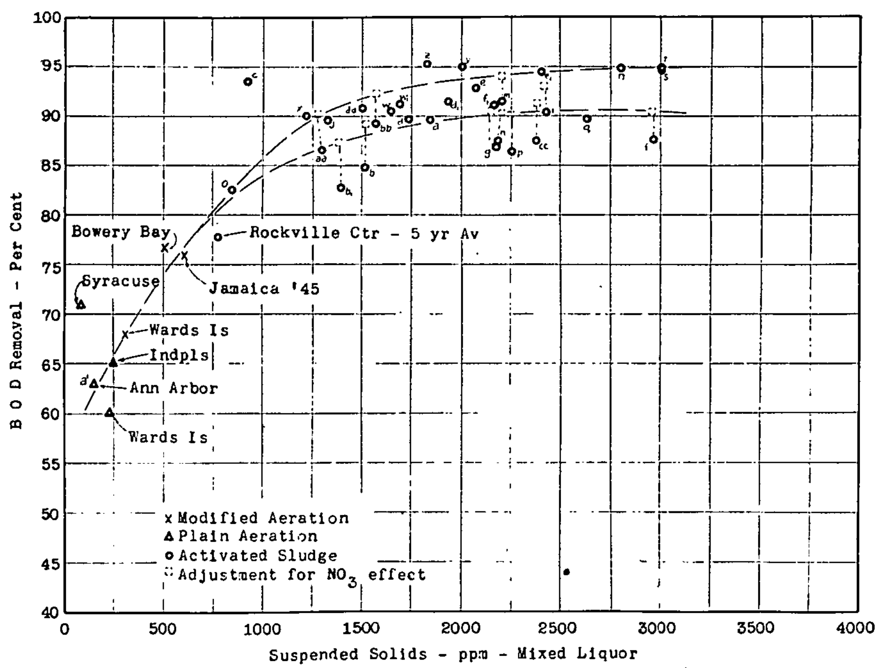


Fig. IV - Mixed Liquor Solids Concentration vs Per Cent B O D Removal mixed liquor solids (ppm) are plotted against per cent removals of BOD. The points are scattered and seem to indicate little or no effect on the percentage figures for concentrations ranging from about 1250 ppm to 3000 ppm.

However, when the results are plotted for plain aeration (at Ann Arbor, Indianapolis, Syracuse, and Wards Island); modified aeration (Bowery Bay, Jamaica, and Wards Island), a short time (1 month) record at Lake Charles, and a published 5-year average for Rockville Center[10] there is a definite indication of a trend curve.

It appears that the data for mixed liquor solids concentrations greater than 1250 ppm must be adjusted or weighted in accordance with other factors before a definite location may be fixed for the trend curve.

Plotted points for certain plants, in which nitrification appears to affect the effluent BOD, have been adjusted, as indicated by dotted squares, by arbitrarily reducing the effluent BOD by 30% and re-computing the percentage removal. This procedure brings all points into closer agreement.

Air Supply Quantities

The quantities of air supplied at the several plants, in terms of the commonly used unit of cubic feet per gallon of sewage, plotted in Figure V against BOD removals, though the points are widely scattered, show a definite tendency toward the use of larger air quantities with stronger sewages. The reported air quantities range from 0.40 at Calumet to 2.41 at Richland Center, Wis. cubic feet per gallon of sewage.

A general trend is indicated (Figure V) toward greater BOD removals, in parts per million, with the higher unit air quantities, but there is only a slight indication of any dropping off in percentage removal of BOD over the entire range of air quantities which might be charged to air requirements.

However, the plotted points are so scattered that no reliable curve can be drawn until some basis has been determined for weighing the several points or the points have been adjusted as to location in accordance with the effect of other factors, possibly factors unrelated to air requirements of the treatment process.

Undoubtedly the air supply quantities are affected by limitations of mechanical equipment, blowers and the like. In certain plants the

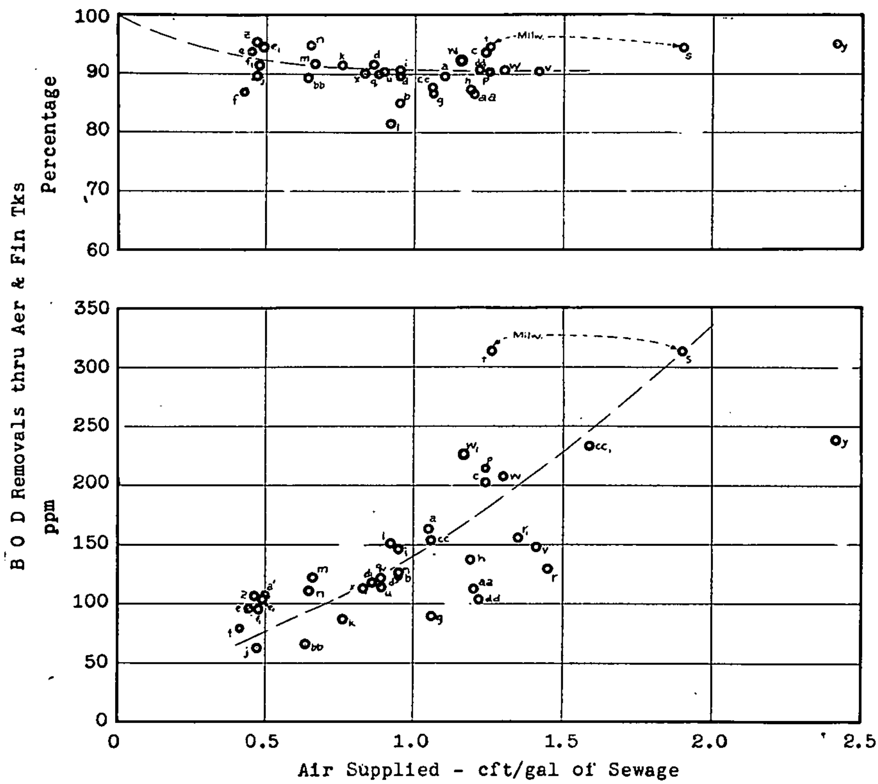


Fig. V - Relation of Air Supplied and B O D Removal

total air supplied remains the same and the cubic feet of air per gallon of sewage varies inversely with the sewage flow rates.

Character of Activated Sludge

Much has been written indicative of some definite relationship between the condition or characteristics of activated sludge, as returned to the aeration tanks, on the efficiency of operation of the plant.

Kraus[4] has reported the effect of adding digested sludge. Both Kraus and Hatfield have used substantial periods of reaeration. Bloodgood[11] and others have attempted to relate the sludge activity, as measured by its use of oxygen, to plant efficiency.

The only factors relating to activated sludge character, generally reported by plant operators, are sludge concentrations (already discussed) and sludge index. As yet no indication has been discovered of any direct relationship between sludge index and BOD removals.

Effect of Nitrification

There has been much thought given to the subject of nitrification. Presently certain plant operators are questioning the desirability of nitrates in the plant effluent. One operator has written that beginning in January 1947 he proposed to operate his plant so as not to produce nitrification, in order that an apparent higher degree of BOD removal might be obtained.

The data on nitrates, from the relatively few plants which have reported nitrates in the plant effluent, have been plotted in Figure VI against BOD removals in percentages. These plotted data seem to indicate higher percentage BOD removals when the nitrates are less than 0.5 to 1.0 ppm, a lower percentage BOD removal when the

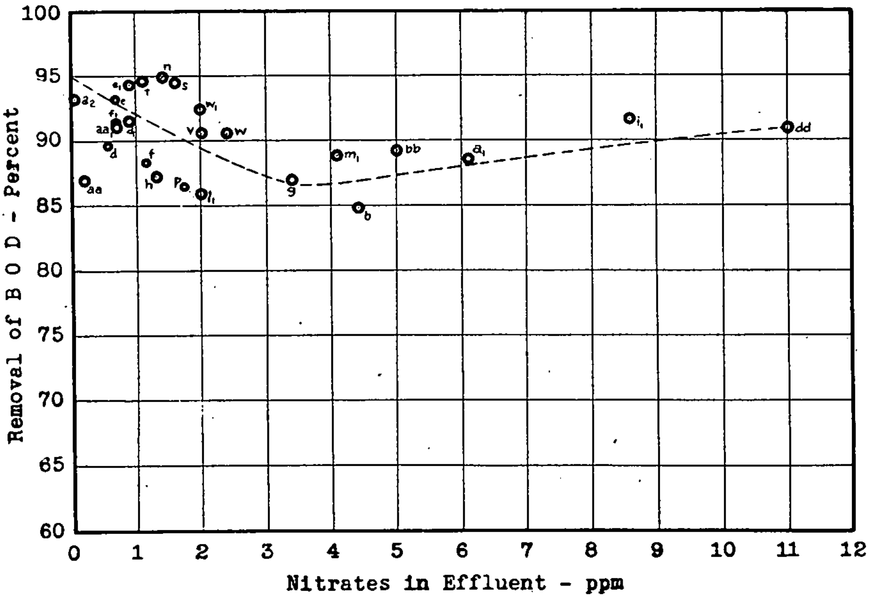


Fig.VI - Effect of Nitrification on Percentage Removal of B O D nitrates are about 3.5 ppm and then an increase in percentage BOD removal as the nitrates go up to 11 ppm.

There seem to be three objections to nitrification: (1) the nitrates may be conducive to undesirable growths of vegetation in the receiving waterway in certain locations, (2) the nitrates may be decomposed in the final sedimentation tanks with resultant rising sludge troubles due to nitrogen gas, (3) the nitrification stage of oxygen demand in the BOD bottles results in higher BOD values for the final tank effluent and thus an apparent lower plant efficiency.

Sawyer and Bradney[12] have discussed the effects of nitrogen gas on rising sludge at Sioux Falls and have suggested the possibility of improvements in the laboratory technique for the BOD test to remove the effect of nitrification on the results of the test.

Hurwitz, Barnett, Beaudoin and Kramer[13] have presented data from Chicago which show that BOD determination for final effluents by a modified technique give values averaging 31.5 per cent lower than results by standard methods.

Kraus at Peoria has tried modified BOD tests for a period of several months (since June 1947). He writes (private correspondence) that the laboratory analyses give final BOD values 20 to 30 per cent lower than formerly found by the standard BOD procedure.

Possibly adjustments in the final effluent BOD values due to the effect of nitrification on the BOD bottles might improve the relative locations of certain plotted points on the several charts (Figures I to VIII, inclusive). Certain adjustments have been suggested by the plotted points in Figure IV determined by arbitrarily reducing the final BOD's by 30 per cent.

More complete analytical data on the nitrogen, in its various forms in the sewage, should be made available before definite conclusions can be developed as to the actual effects of nitrification.

More Complex Parameters

Analytical procedures involving simple comparisons of the values of daily BOD removals with each of the several influential factors, outlined hereinbefore, have not given conclusive evidence of the magnitude of influence of each individual factor.

Accordingly, consideration has been given to more complex parameters for determining the proper capacity of a proposed aeration plant, starting with the daily BOD quantities in the settled sewage.

The several more complex parameters so far studied have included:

a) P_1 = Applied BOD in pounds daily per 1000 cubic feet of aeration tank volume (including any sludge reaeration volume).

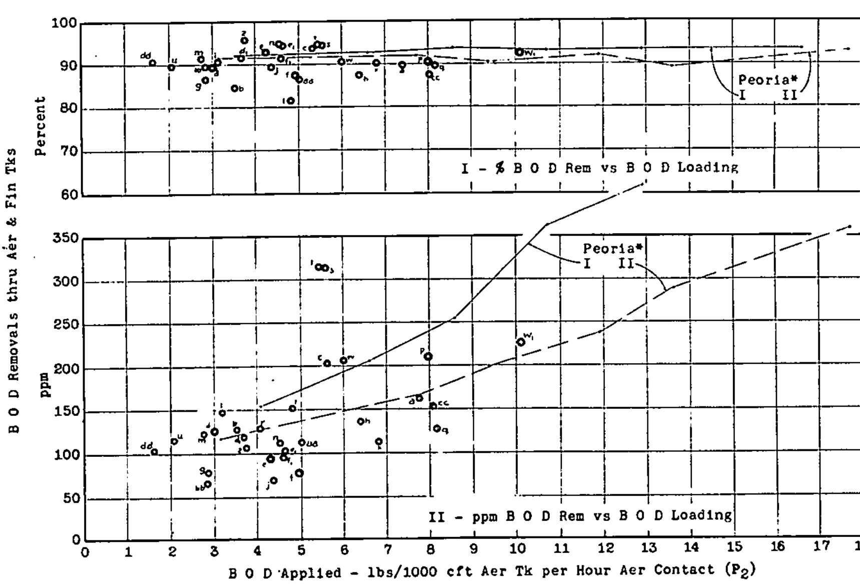
b) $P_2 = P_1$ divided by the hours of aeration contact period.

c) $P_3 = P_2$ divided by the ppm of suspended solids in the mixed liquor and multiplied by 1000 (to give numbers greater than 1.0).

d) $P_4 = P_3$ divided by the cubic feet of air per gallon of sewage.

The P_1 parameter values (lbs. BOD applied daily per 1000 cubic feet of aeration tank volume) have already been related to BOD removals (Figure I).

The P_2 parameter values, i.e. pounds BOD applied daily per 1000 cubic feet of aeration tank divided by hours aeration contact time, compared to BOD removals are shown graphically by Figure VII. These values ranging from about 1.5 to about 18.0, give scattered points (Figure VII) which show no definite trend. Also



Ref*
* Special Tests by Kraus (ltr)

Fig. VII - B O D Removals vs B O D Applied lbs/1000 cft Aer Tk per Hr Aer Contact there is no evidence of any reduction in percentage removal for P_2 values less than 18.0.

The interrelation of the several parameters (P_2, P_3, and P_4) with the BOD loading, P_1, for the second, third and fourth degrees of complexity, is recorded as parts I, II and III of Figure VIII.

The plotted points (Figure VIII) are scattered due to unde-

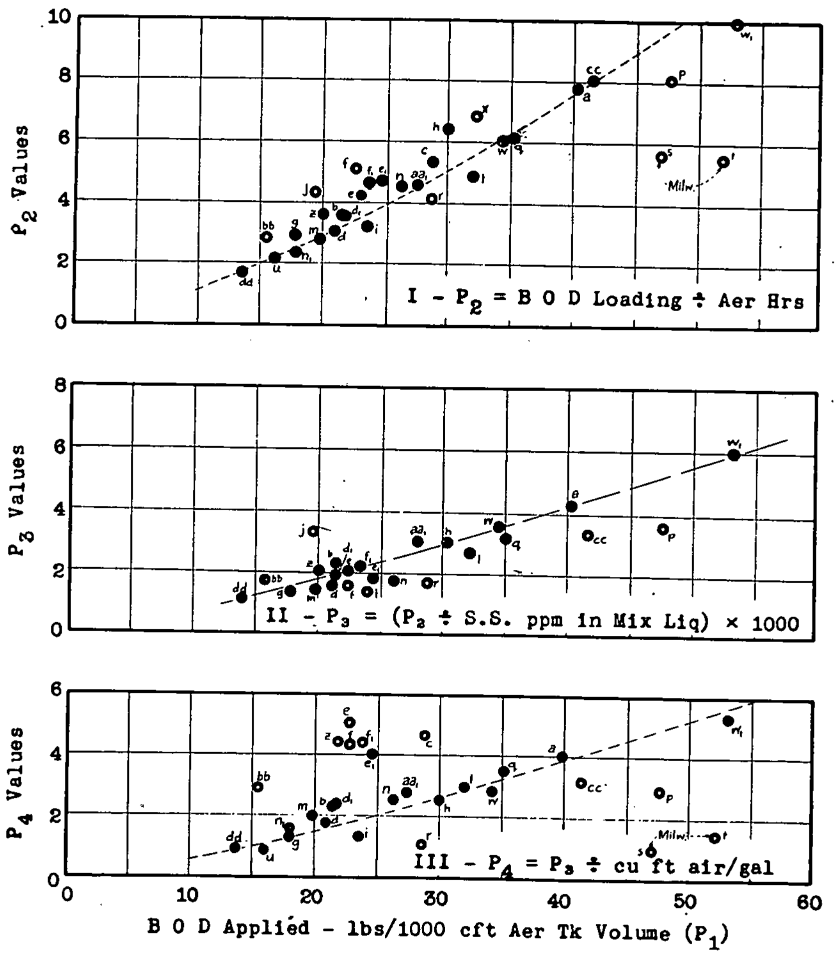


Fig. VIII - B O D Loadings on Aeration Tanks (P_1) vs Parameters P_2, P_3 & P_4

termined causes. However, a selection of the more consistent data, indicated by the solid points gives encouragement to the expectation that proper adjustments may be discovered soon which will account for the influences of various factors presently unknown or unevaluated and established a certain definite parameter directly applicable to the design of new plants.

SUMMARY

Operating data from 27 activated sludge plants (Table I) studied by plotting four major factors against BOD removals have indicated roughly the relative magnitude of the effect of each factor: (1) BOD loading (Figure I), (2) aeration contact hours (Figures II and III), (3) solids concentration in the mixed liquor (Figure IV), and (4) air quantities supplied per gallon of sewage (Figure V).

However, the plotted points are sufficiently scattered as to suggest that other factors must be included before any real basis of design factors may be established. Among these other factors may be:

a. The chemical character and nutritional quality of the organic matter in the sewage.
b. Temperature.
c. Nitrification or the stage of decomposition and nitrification of the nitrogenous matter during the sewage treatment. Some approximate indication of the effect of this factor has been indicated (Figures IV and VI).

Further, the graphical analytical procedures have shown none of the four major factors as the principal influence in the results which may be expected from the operation of an activated sludge plant. Thus, the combined influence of all factors must be considered.

Certain data from plain aeration and modified aeration experimental operation of activated sludge plants suggest (Figure IV) that the concentration of suspended solids in the mixed liquor may have more influence than sometime has been considered to be the case, particularly for mixed liquor concentration less than about 1800 ppm.

There is some evidence that nitrification does result in lower apparent BOD removals under certain conditions. These indicate the desirability of modifying the Standard BOD laboratory technique to rule out the effects of nitrification in the BOD bottles during the

5-day incubation period. Laboratory procedures for this have been proposed by Sawyer[1] and by Hurwitz, et al.[13]

A graphical comparison (Figure VIII) of the four parameters, of the first, second, third and fourth degree of complexity, with the P_1 parameter—BOD lbs. applied per 1000 cubic feet of aeration tank volume—gives encouragement to the hope that shortly a key may be found to the interrelationship of the several influential factors.

Studies must be continued and additional operating data analyzed to establish a sound procedure for the design of aeration plants with reference to the BOD of the applied sewage. Meanwhile the basis of design proposed by Greeley, i.e. 25 to 30 lbs. BOD per 1000 cubic feet of aeration tank volume, appears to be a very conservative basis for domestic sewage.

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MUNICIPAL ENGINEERING SURVEYS

BY FRANK L. CHENEY, MEMBER*

(Presented at a meeting of the Surveying and Mapping Section of the Boston Society of Civil Engineers held on April 7, 1948.)

Municipal engineering surveys should be made, in my opinion, as accurately as possible, as economically as possible, and usually, in order that they may be used for the purpose intended, as speedily as possible. Other methods may be more desirable than these that I refer to, and undoubtedly conditions will warrant different procedures.

A short history of the surveys in Needham might be of interest. Until about twenty years ago the only traverses or base-lines of any extent run in this town with any accuracy, to my knowledge, were those on the County highway layouts.

Since 1930, we have nearly covered the entire town by a network of survey traverses connected to each other and to the existing triangulation points and town bounds.

Beginning about 1931, I used the principle triangulation points as a basis for establishing a system of coordinates with the State House as the origin, or South = 0 and West = 0, and thereby attempted to coordinate the traverses in existence at that time.

With the assistance of E.R.A. and W.P.A. we covered much more ground and in 1936 the Massachusetts Geodetic Survey offered to run surveys and place monuments in locations that I thought would be desirable for future use, in addition to those already in existence at that time. These monuments were all referred to the Massachusetts Coordinate System, so, as soon as practicable I started to place all our traverses on this system. In order to do this, angles and distances were measured to all nearby stone bounds, etc., from the various M.G.S. monuments. The traverses and layouts were then computed and balanced on the Massachusetts Coordinate System of 1941.

I would like to suggest that coordinates should be dated. In using the Massachusetts Coordinate System, changes or adjustments might be made at any later date in the published values of the coordinates of the Massachusetts Geodetic Survey monuments.

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By placing the notation "Massachusetts Coordinate System", "1941" on the north point, it gives any other engineer the date of the values used and might save a serious discrepancy sometime in the future.

Traverses should be made with the idea in mind of locating as many details as possible, such as monuments, walls, property corners, buildings and other physical features. This is particularly desirable for streets having no definite layout lines and for use in making Assessors Plans.

They should be useful also for the layout of a street, that is, in the establishment of lines or a relocation. I believe that angles and distances taken to substantial buildings or their foundations, whereby the co-ordinates may be computed, are better than offsets. By showing co-ordinates of corners of foundations, offsets may be computed therefrom at any future date and may be more permanent than stone bounds.

The Town Map of Needham in general use until 1945 was made up about 1923 from various surveys and plans of doubtful accuracy. While it probably served its purpose at that time, numerous errors existed.

The plotting of traverses by co-ordinates, on a 400 foot scale, enabled us to find where additional lines might be needed in the future, and, at the same time, use it as a basis for a new Town Map, which we made.

While on the matter of Town Maps, it might be well to mention that the U. S. Geological Survey Maps may be enlarged up to a 400 foot scale, or larger, and thus a very good contour map may be made of a Town in this manner.

The Assessors plans which we have are the results of my own personal ideas of what should be shown, and what the Assessors desired. We traverse as much as we can or feel necessary, and fill in the balance from Land Court plans and all other surveys and plans available.

I have found that the use of co-ordinates on street layouts is very desirable and recommend their use whenever possible. An example of this was in a recent street layout which I made near two other streets having balanced co-ordinated baselines run along them. By using deeded distances and other data, I was able to compute the lines of the new street, and later, found that when we laid it out on the ground, it checked out very well.

Another reason for using co-ordinates is that they can be used for different purposes. For instance, we had a co-ordinated line on an old street that had no definite layout lines. In other words, the boundaries are old walls or what remains of them; fences, and other lines of occupation. We used this co-ordinated baseline for the Town Map and Assessors Plans. Last year we constructed a sewer in this street and again used the same line for showing the street lines, property lines, and buildings. Each time we plotted the line on a different scale. For the Town Map a 400-foot-to-an-inch scale was used, for the Assessors plans an eighty-foot scale was used, and for the sewer record plans a scale of 40-feet-to-an-inch was used.

In making surveys for sewer easements, I have found that, by running a traverse between monuments that have been co-ordinated, it gives a definite check on the field work.

The equipment that we use is an engineers transit, and I feel that it should be cleaned and adjusted nearly every year for good results; a 100-foot steel tape that has not been spliced or repaired, if possible, and also, it should be one of the narrow type tapes to lessen wind resistance; a Locke or hand level for use in leveling both ends of the tape, and an oval-shaped red and white plumb-bob target, such as manufactured by Dietzgen. This target I believe is invaluable for sights two or three hundred feet or more away, especially where a plumb-bob string might blend into the background, or on difficult sights. We also have a large wooden red and white target about fifteen inches square mounted on two-by-three, six feet long, for use on sights half a mile or more away. This target may be carefully erected over a monument and held in place by nailing it to stakes driven into the ground at an angle.

Another device that I have found useful when short of assistance, is a light tripod. This may be a light mountain transit tripod or a camera tripod. By setting this over a backsight and hanging a plumb-bob from it by means of a large flat-sided spike, as many angles can be turned from it as desired.

For best results, the tape should be checked for accuracy against a standard and the proper pull or tension applied to all measurements. The temperature should be noted and the correction applied.

One piece of equipment that I do not use and do not recommend, is the range-pole or the sight-pole. I prefer to use a plumb-bob for lining-in points for measuring and sights for turning angles.

The number of repetitions of an angle depends on the length of sights. I have used three repetitions mostly and have received good results therefrom. An idea of what happens when angles are not repeated or turned close enough, is shown as follows:

Angle turned to the nearest 0°-01'-00"-in 100 feet, may vary about ½ of 0.03 or .015 feet.
" " " " " 0°-00'-30" in 400 feet, may vary about ½ of 0.06 or .03 feet.
" " " " " 0°-00'-10" in 400 feet, may vary about ½ of 0.02 or .01 feet.

The error of closure of some of our more recent traverses are as follows:

1 in 51980 (The angular closure was 0°-00'-27")
1 in 43360 (" " " " 0°-00'-20")
1 in 35990 (" " " " 0°-00'-35")
1 in 28600 (" " " " 0°-00'-05")

The preceding data has dealt principally on horizontal measurements. Briefly, our levelling is no different probably than in other Engineering offices. The Needham Base or Datum is supposedly the same as the Metropolitan Sewer and we are able to use the Massachusetts Geodetic Survey monuments by adding 105.64 feet to their elevations. We use the self-reading or tape rod, as manufactured by Lenker, as it eliminates any possibility of error in computing the H.I., and it saves much time where many elevations are to be calculated as in cross-sections, etc.

In conclusion, I wish to state that from my experience the accuracy attained in making a survey depends a great deal on the human element. Conscientious, dependable and qualified personnel determine to a great extent what the results will be.

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ASSESSMENT AND CONNECTION PRACTICES IN BRAINTREE

GEORGE F BROUSSEAU, MEMBER*

(Presented at a meeting of the Sanitary Section of the Boston Society of Civil Engineers, held on October 2, 1946.)

By means of sewer assessments a municipality may apportion part of the cost of construction of a sewerage system directly against property that is immediately benefited by the improvement. A special act of the General Court, Chapter 17, Acts of 1930, provided for the construction of sewers and levying of sewer assessments in the Town of Braintree in accordance with the provisions of General Laws, Chapter 83.

While both the special act and general laws provide that the Town shall pay not less than one-quarter nor more than two-thirds of the whole cost of the system of sewerage, considerable latitude is allowed in determining the cost and in fixing the assessment rate. The authority for the method and application of the assessment is Chapter 83, sections 14 and 15, of the General Laws.

Section 14. "A person who enters his particular drain into a main drain or common sewer or who by more remote means receives benefit thereby for draining his land or buildings, shall pay to the Town a proportional part of the charge of making and repairing the same and of the charge, not already assessed, of making and repairing other main drains and common sewers through which the same discharges, which shall be ascertained, assessed and certified by the aldermen, sewer commissioners, selectmen or road commissioners."

Section 15. "The city council of a city or town may adopt a system of sewerage for a part or the whole of its territory, and may provide that assessments under section fourteen shall be made upon owners of land within such territory by a fixed uniform rate, based upon the average cost of all the sewers therein, according to the frontage of such land on any way in which a sewer is constructed, or according to the area of such land within a fixed depth from such way,

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or according to both such frontage and area; but no assessment in respect to any such land, which by reason of its grade or level or any other cause cannot be drained into such sewer, shall be made until such incapacity is removed. If the assessment is according to the area within such fixed depth, the lien therefor shall attach to the parcel assessed."

Before recommending a sewer assessment rate for Braintree, studies were made of what had been done in neighboring communities. An excellent paper on Sewer Assessment Practice in Massachusetts by Paul F. Howard, March, 1933 provided very helpful material. It was finally decided that a rate of $2.00 per front foot represented the maximum rate the property could stand—this was in November, 1933. Using only estimated construction costs it was shown that an apportionment of 55% to 75% of this cost against sewer assessments could be justified by a $2.00 rate. At a special Town Meeting in November, 1933, the Sewer Commissioners proposed that the town pay 40% of the cost of the sewerage system and that the remaining 60% be raised by sewer assessments as follows:

"Assessments shall be made upon owners of the land according to the frontage of such land on any way in which a sewer is constructed at the rate of one dollar per linear foot of such frontage and according to the area of such land within a fixed depth of 100 feet from such way at the rate of one cent per square foot of such area; these rates having been found and determined to be each one-half of the estimated remaining cost."

The Town Meeting voted to adopt the method of assessment proposed by the Sewer Commissioners.

The application of Braintree's sewer assessment rate for the past thirteen years may be summarized as follows:

1. *General:*

    a. Fixed uniform rate of $1.00 per foot of frontage plus 1¢ per square foot of area for a depth of 100 feet.
    b. Separate assessment for each lot.
    c. No double or overlapping assessments.
    d. No consideration for size, value or use of land.
    e. No consideration for size or cost of sewer constructed.

2. *Area Determination:*
   a. Assessed area is bounded by lot lines, frontage and a line parallel to and 100 feet back from the frontage. For rounded corners at street intersections, the area limit of assessment is made parallel to the tangent of the arc.
   b. Assessed area may equal but not exceed the area of the lot.
   c. No area assessment is made unless there is some frontage to go with it.
   d. Area assessments are deferred on land lying below a plane rising at a grade of 2 per cent from the crown of the sewer main, until such time as the land is filled above this plane or until another sewer is constructed in a right of way or street that could serve such land.
   e. Areas are taken as shown on the Assessor's Plan or computed by using dimensions shown on Assessor's Plans or deeds. Irregular areas, or areas difficult to compute, are planimetered and recorded to the nearest 50 square feet.

3. *Frontage Determination:*
   a. Assess straight or curved frontage, as shown on Assessor's Plans or deeds, on both sides of street.
   b. Assessment is deferred on frontage adjacent to area that lies below the level of the sewer. No frontage assessment is made unless there is some area to go with it.

4. *Corner Lots—Sewer in Only One Street:*
   a. Assess straight or curved frontage along sewered street plus ½ the arc if corner is rounded, or plus ½ the chord if corner is cut but not rounded.

5. *Corner Lots—Sewers in Two Streets:*
   a. Both sewers constructed in the same year. Assess frontage on longest side on one street plus remaining frontage on other street extending beyond 100 foot area limit of assessment.
   b. Both sewers not constructed in the same year, previous sewer assessment made on longest frontage: Assess remaining frontage on second street extending beyond 100 foot area limit of assessment for first street.

c. Both sewers not constructed in the same year, previous sewer assessment made on shortest frontage: Determine frontage assessment by application of #5a and then credit the previous frontage assessment.

6. *Corner Lots—Sewers in Three Streets:*

a. All sewers constructed in the same year. Assess frontage by taking longest sides in order and proceeding as in #5a.
b. Sewers constructed in different years. Determine frontage assessment by application of #6a and then credit the previous frontage assessments.

7. *Lots Extending Between Two Parallel Sewered Streets With Frontage on Both Streets:*

a. Where the distance between the two streets is 200 feet or more. Assess the total frontage on both streets.
b. Where the distance between the two streets is less than 200 feet. Assess the longest frontage, and corresponding area to a depth of 100 feet. Assess the frontage on the second street in the proportion the average remaining depth bears to 100. Assess the remaining area.

8. *End of Line—Dead End Manhole:*

a. Full frontage and area assessment for all lots the sewer can serve. Where the property has not been divided into lots, assess for 100 feet beyond the dead end manhole.

9. *End of Line—Summit Manholes—No Sewer in Between:*

a. Limits of assessment same as #8.

10. *Property Not Previously Assessed Is Connected With Sewer:*

a. Assessment determined by what it would be if sewer were laid in street in front of property.
b. If a partial assessment was levied under #8 or #9 the remainder is now levied.
c. Where property has not been divided into lots, assessed frontage is taken same as average adjacent property division but not less than 50 feet nor more than 75 feet. ($100 and $150 lump sum assessment respectively.)

d. Additional bulding in rear, beyond assessed area, connected to sewer. Lump sum assessment of $100.
e. Manufacturing Plants—Each case considered separately—Lump sum assessment of about 1 per cent of assessed valuation.

11. *Sewers in Easements or Right of Ways:*

a. Where a property sub-division plan has been recorded showing street layout and lots, sewer is laid in center of proposed street and full assessments are levied.
b. Where a sewer is laid through private property which has not been sub-divided into streets no assessments are levied, except if a connection is made with the sewer, then assessments are as under #10.

12. *Sewers in New Developments Constructed at the Expense of the Developer:*

a. Full sewer assessments for all lots on which buildings are erected. No assessments levied on vacant lots until built upon or until street is accepted by the Town—then full assessment.

13. *Property Exempt from Assessment:*

a. Town owned property.
b. Deeded right of ways.
c. Railroad legal right of way for width of 82.5 feet.

Previous to this year at dead end and summit manholes, the frontage and area limits of assessment were bounded by a line through the center-line of the dead end manhole and at right angles to the street line. Also, beginning this year, the procedure for corner lot assessment was changed. Previously, when sewers were constructed in different years, only the remaining frontage on the second street extending beyond the 100 foot area limit of assessment for the first street was assessed.

If a builder desires to establish a system of sewers within a new development, he must build them according to the Sewer Commissioners' specifications and must pay the whole cost of the installation. The Sewer Commissioners will furnish the layout, line, grade, inspection and extend the present sewer system to pick up the new development. Assessments are levied as outlined under #12.

Assessments were levied against all church property normally exempt from taxation, although a partial abatement was made according to a special plan where by all paid about 44% of the original amount assessed.

Payment of sewer assessments may be apportioned over a period of ten years, provided no apportionment is less than five dollars. interest is charged at 4% annually on the outstanding balance. The Assessors automatically apportion all unpaid assessments over the maximum number of years allowed, unless a special apportionment is requested.

Whenever the Sewer Commissioners decide to undertake new sewer construction, a copy of the order, list of ways and estimated assessments are filed in the Norfolk County Registry of Deeds. Final assessments together with a reduced copy of the assessment plan are filed in the Registry after the assessments have been certified to the Board of Assessors. No blanket discharge of sewer liens has ever been filed at the Registry of Deeds.

The following is a summary of certain record data regarding sewer assessments in Braintree:

From the year 1931 to 1945 inclusive, 23.3 miles of main and lateral sewers were constructed at a cost of about $840,600. Assessment levied for this construction amounted to $300,165, or an average of about 36% of the total construction cost. This percentage has varied over a wide range as shown by the following tabulation:

Year	Kind of Work	Assessment Per Cent of Construction Cost
1931	Contract — Main Sewers	24%
1933	Force Account — Lateral Sewers	58%
1935	P. W. A. — " "	42%
1936 & 1937	W. P. A. — " "	115%
1938 to 1940	W. P. A. — Pumping District	25%
1941	Contract — Lateral Sewers	60%

On account of street intersections and non-assessable Town property, the assessable frontage will never equal twice the length of the sewer. It has varied from 67% to 83% for different years. The average is 79% or 1.58 times the length of the street sewers. In arriving at these percentages the length of sewers in right of ways has not been included.

The distribution of the total assessment between frontage and area runs fairly constant: Frontage 53%, Area 47%.

Between 50% to 70% of the assessments are apportioned over a ten year period of time. Interest collected has amounted to $41,847 or 14% of the assessment levy.

The greater portion of the construction cost was financed by issuing $755,000 of serial bonds maturing over a period of thirty years. The interest to maturity on these bonds will amount to $336,623. The following tabulation shows the various rates of interest paid for sewer bonds.

Year of Borrowing	Amount Borrowed	Years to Maturity	Interest Rate
1931	$444,000	30	3½%
1933	93,000	20	5%
1935	150,000	20	3¼%
1941	68,000	10	1%

Braintree is a member of the South Metropolitan Sewerage District and the Metropolitan charges, which were not included in the estimated cost of construction, have averaged about $16,500 per year. The charge for 1945 was $13,230. The entrance fee was $80,205.

Sewer Connection Practice in Braintree

All connections to the sewer system are made by the Braintree Sewer Department upon application of the owner. Vitrified clay sewer pipe, 5-inch or 6-inch diameter, is used with "Puroseal" or "G-K" jointing compound. Where the pipe is laid near tree roots, a collar of cement and copper sulphate is used in addition to the asphalt jointing compound. The vitrified pipe is laid on a bed of four to six inches of screened gravel which is carried up at least half way on the pipe. Where the cover in the street is less than 4 feet, the pipe is protected with a concrete encasement. The minimum cover at the building is 3½ feet. The minimum slope from the sewer in the street to the building is 2%. The connection ends at the inside wall of the building with a 5-foot length of 4-inch extra heavy cast iron soil pipe. The pipe is sealed with a cast iron stopper tightly caulked into place.

When the connection is completed, a notice is sent to the owner together with a duplicate copy of the application. At the end of the month, following that in which the work was done, the owner is billed for the actual cost of the work. This charge becomes a lien against the property and may be apportioned over a ten year period, the same as sewer assessments. Chapter 45 of the Acts of 1936 authorized the Town of Braintree to assess sewer connection charges.

The distribution of cost of making a sewer connection during the past few years has averaged about: 63% Labor, 15% Equipment and 22% Materials.

The following tabulation shows how the cost of making sewer connections has varied from year to year:

Year	Number of Connections	Ave. Cost Per Foot	Ave. Cost Per Connection
1934	84	$2.04	$86
1935	83	1.51	82
1936	107	1.63	102
1937	120	1.46	79
1938	80	1.55	80
1939	61	1.53	96
1940	93	1.52	77
1941	179	1.87	98
1942	64	1.91	104
1943	34	2.69	144
1944	50	2.73	137
1945	59	2.62	131
1946	97	2.55	128

A- refers to appendix paging

ASSESSMENT AND CONNECTION PRACTICES IN THE TOWN OF NEEDHAM

By Norman M. Winch*

(Presented at a meeting of the Sanitary Section of the Boston Society of Civil Engineers, held on October 2, 1946.)

The sewerage system of the Town of Needham is operated under provisions of Chapter 50 of the Acts of 1924. This Act which was adopted by the Town at a special meeting held March 17, 1924 provides for the admission of Needham sewage into the South Metropolitan Sewerage System and authorizes the town to construct and operate a system of sewers.

Section 9 of the Act provides that the Town may choose what proportion of the cost of the system of sewers it will pay directly from its funds, providing that it shall so pay not less than one fourth or more than two-thirds of the total cost. For the remainder of the cost the Town may avail itself of all, or any of the provisions of the General Laws relating to assessments. In May 1925 the Sewer Commissioners voted that the assessments for sewer construction be divided on the basis of 40 per cent for frontage and 60 per cent for area.

At a special town meeting held in May 1925 the Town voted that in accordance with the Act the town should pay one-third of the cost of the system or systems of sewerage and sewage disposal. At the same meeting the town further voted that the remaining cost of the Town system should be divided as follows:

"Assessments shall be made upon owners of the land according to the frontage of such land on any way in which a sewer is constructed, at the rate of $.64 linear foot of such frontage and according to the area of such land within a fixed depth of 100 feet from such a way at the rate of $.01 per square foot. These rates have been found and determined to be respectively four-tenths and six-tenths of the estimated remaining cost. When any of the foregoing methods cannot be applied, any person who uses the main drain or common sewer in any manner instead of paying the assessment under General

*Superintendent of Sewers, Needham, Mass.

Laws, Chapter 83, Section 14, shall pay for the permanent privilege of this estate such reasonable amount as the Sewer Commissioners shall determine."

At this point it might be well to explain how the figures of \$.64 and \$.01 were derived. It was determined from experience in other Towns that assessable frontage approximates 1.75 times the actual length of possible sewer construction. The total length of the system was estimated to be 150,224 feet and by applying the aforementioned factor the assessable frontage was estimated to be 263,000 feet. The committee setting up the assessment program after some study, arrived at the conclusion that a depth of 100 feet from the street line was a just and equitable limit to determine assessable area. On a 100-ft. depth basis it was estimated the assessable area would be approximately 25,200,000 square feet. Based on these estimates the assessments were computed as follows:

Estimated cost of Sewer system	\$575,000.
Entrance Fee S. Metropolitan	55,000.
Total Cost of System	\$630,000.

Portion of cost to be apportioned on abuttors
2/3 of \$630,000—\$420,000.

Frontage $4/10 \times 420{,}000 - \$168{,}000$

Assessment per foot of frontage $\dfrac{\$168{,}000}{263{,}000} = \$0.639$, say \$0.64

Area $6/10 \times 420{,}000 = \$252{,}000.$

Assessment per sq. ft. of area $\dfrac{252{,}000}{25{,}200{,}000 \text{ sq. ft.}} = \$0.01$

For the ordinary rectangular lots 100 feet or more in depth this is equivalent to \$1.64 per running foot of frontage.

In the case of corner lots, 60 feet of the frontage on the second street and all area within 100 feet of the first street is exempted in figuring assessments for the second street. Any frontage on the second street beyond 60 feet from the first street is assessed at the rate of \$0.64 per foot frontage and any area over 100 feet from the first street but within 100 feet of the second street is assessed at the rate of \$.01 per square foot. It is the practice of the town to assess a lot on the basis of the sewer first constructed and to apply the exemption to the second sewer constructed.

Property beyond the 100 foot limit of assessment is assessed at the rate of \$.0164 per square foot at the time a "particular sewer" (legal terminology for house connections) is installed to serve the property.

Land that is too low to drain into the sewer is not assessed at the time of sewer installation. When such land is built upon, the assessment is then levied. Property owners desiring to connect to the Metropolitan sewer directly are required to pay a charge of \$150. This is not an assessment but is a payment for the permanent privilege of connecting the estate to the sewer and is based on the assumption that an average lot contains approximately 10,000 square feet.

It has been made a practice to assess Town property when the sewer is installed in front of such property. This is handled by grouping all such assessments made during the year and appropriating money under a special article at the Town meeting to reimburse the sewer assessment fund.

In cases involving dead end manholes only the lots which can be served are assessed. Where a lot at the end of a sewer is large the abutter is notified in advance so as to give him an opportunity to file a sub-division of his property and thereby reduce his contribution. Chapter 80, Section 15, General Laws which governs the division of assessments, requires that a lien apply to a whole lot.

A comparison of the cost of sewer constructed and assessments levied by years follows:

	Cost	Assessment levied
1926	151,390.42	64,351.44
1928	36,174.83	40,650.90
1930	38,337.02	19,704.32
1932	12,142.90	7,949.43
1934	29,802.19	5,697.71
1937	13,634.37	20,347.11
1941	28,984.13	14,908.30
1945	2,042.03	898.92

During the period from 1932 to 1934 a large construction program was carried on as a part of a relief program for the unemployed. Sewers were installed in certain streets but not connected for service and therefore the abuttors were not assessed. This accounts for the low assessment return during that period. In 1937 most of such sewers were connected for service and the properties assessed which accounts for the high assessment return during that year.

As of the first of January 1945, the total cost of the works was $551,258.07, and total assessments levied was $306,707.29. This is for a system of 24 miles of sewers. The length of sewers and estimated cost used in figuring the assessment rate in 1925 are rapidly being approached. This original estimate was based on 28½ miles of street sewers, interceptors, two pumping stations and force mains at an estimated cost of $575,000.00. Experience shows that the assessment rate established in 1924 was too low. When the cost of works and length of the sewer system reaches the original estimate a revision upward of the assessment rate will be necessary. This will be due to the higher construction costs which will no doubt prevail in the future. It is doubtful that labor and material costs will ever again drop to the levels we have experienced in the period just past.

House Connections

The construction of particular sewers, or as we call them, house connections, is carried on by Town forces. The procedure from 1925 up to 1934 was for the property owner to sign an application and request an estimate of the cost of making the connection. An estimate was made and bill sent to the property owner. The property owner was then required to deposit with the Treasurer an amount, equal to the estimate. Upon completion of the work an adjusted bill was rendered and the property owner given a rebate or was obliged to pay an additional amount depending on how the bill compared with the estimate.

The above procedure was changed in 1934 when the Town voted to adopt Chapter 29 of the Acts of 1934 which provides that the cost of particular sewers shall be assessed and apportioned under the General Laws relating to assessments. Under the new procedure the applicant must be the owner or the owner's agent. The application has provision for an estimate of cost of the connection so that the owner may obtain some idea as to possible expense. Upon completion of the connection a warrant or certificate is drawn up and signed by the Selectmen. This certificate is then given to the Tax Collector and is also filed at the Registry of Deeds. The Collector issues a bill to the applicant and if this bill remains unpaid the assessors automatically apportion the amount of the bill over a period not exceeding ten years and bearing interest at the rate of 4 per cent. No installment of less than $10 is set up. Interest charges commence thirty days after receipt of the certificate by the Collector.

The following table lists by years the number of house connections installed, their total length and the average cost per foot:

HOUSE CONNECTION COSTS

	No.	Total length	Av. cost per foot
1926	66	4223	$1.48
1927	70	4592	1.34
1928	76	4720	1.20
1929	98	6022	1.28
1930	62	4287	1.24
1931	61	4306	1.15
1932	50	3615	0.82
1933	59	3491	0.83
1934	86	5347	0.93
1935	88	4489	0.95
1936	91	5637	1.04
1937	126	7146	1.02
1938	68	4199	1.02
1939	73	4576	1.13
1940	66	4032	1.17
1941	103	5481	1.17
1942	44	2515	1.42
1943	36	2307	1.54
1944	51	2894	1.63
1945	42	2639	1.80

The average cost per foot of house connection in 1926 was $1.48. In 1932 and 1933 the cost had dropped to $0.82, but it rose to $1.17 in 1940 and to $1.80 in 1945. During the present year (1946) it appears that the average cost may run as high as $2.50.

LONG DURATION IMPULSIVE LOADING OF SIMPLE BEAMS

By Robert J. Hansen*

(Presented at a meeting of the Structural Section, Boston Society of Civil Engineers, held on March 10, 1948.)

Introduction

A number of dynamic problems have been of concern to civil engineers. Two of the more prominent of these have been the problems of design of structures to resist earthquakes, and the provision of additional strength in bridges to resist impact forces. Although these problems have been handled in simple empirical manners, the exact analysis in either case has been studied. Other dynamical problems which have had the attention of engineers, although not primarily civil engineers, are those of the wing flutter on airplanes and the vibrations of engines and other moving mechanical systems.

An exact dynamical theory for the behavior of elastic systems under the action of impulsive loads was developed a few years ago, and this theory was simplified and many applications to specific problems were made.[1] The theory was put in such form that it could be applied by normal routine design procedures for some of the simpler elastic systems.

In general, the various structural materials in use behave very differently under shock or dynamic loads than they do under static loads. The allowable stresses for design purposes may be much higher if the structure is subjected to an impulsive load. To completely equip the engineer so that he can design structures to resist impulsive loads, it is necessary to supply him with allowable stresses for concrete and steel. Such stresses were deduced from a large number of experiments made a few years ago; some of these were a series of impact tests run on small reinforced concrete beams.[2]

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[1]Robertson, H. P., and Slutz, Ralph J., The Reaction of Thin Beams and Slabs to Impact Loads. Part I. General Theory; Part II. Beams. National Research Council. Washington. D.C.

[2]Munse, W H., and Richart. F. E, Impact Tests of Reinforced Concrete Beams, III, National Defense Research Committee Report A-304.

The allowable stresses deduced from the tests mentioned were for an impulsive loading of short duration compared to the fundamental frequency of the elastic systems under test. For these short duration pulses, the allowable stresses for design purposes were found to be of the order of ten times those allowable for static stresses.

Recently interest again turned to the impulsive load problem, but this time to the case in which the impulse is of long duration when compared to the fundamental frequency of the elastic system to be loaded. In this case, the exact theory developed earlier would still hold true; however, the permissible fiber stresses probably would not. In fact, they probably would be lower than those which had been specified for the shorter duration impulsive loads. An experimental program to determine what the permissible design stresses should be for the long duration impulsive loading was started at M. I. T. on April 15, 1947, and this paper describes briefly the testing machine that was designed and constructed, the instrumentations procedures used, and some very tentative results obtained so far.

Requirements for and Design of Testing Machine

The nature of an impulsive load is illustrated in Figure 1. As shown, an impulsive load is one which varies in intensity with time.

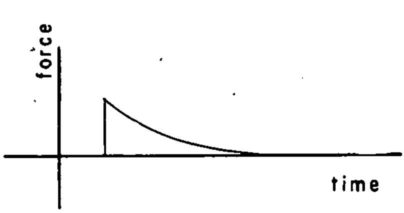


Fig. 1

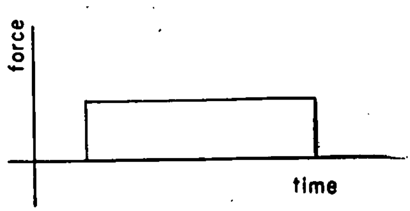


Fig. 2

In practice, this load is applied uniformly over a portion, or portions, or over all of the structure to be designed. By its nature, it has no mass or inertial effects associated with it; in this manner it differs from the impact loads associated with the passage of locomotives passing over bridges, or the torsional vibrations of crankshafts of motors.

The nature of the impulsive load established several requirements to be met in the design of the testing machine. These requirements were:

a. The pulse should be controllable as to magnitude and duration,
b. the pulse should have as sharp a wave front as possible,
c. a pulse of 10,000 lbs-secs would be required,
d. the force-time shape of the pulse should be nearly rectangular, and
e. the behavior of the test specimen should have little or no effect on the pulse.

In general the force-time curve of the applied load should be as shown in Figure 2. The load should preferably be uniformly distributed over the test specimen, but if this were not possible, it would be permissible to use a concentrated load. In the light of these requirements, several methods for producing the pulse were studied.

It would be simple to build an impact machine, that is, a machine in which the dynamic load is produced by a falling or rapidly propelled weight. But this method was ruled out by requirement *e*.

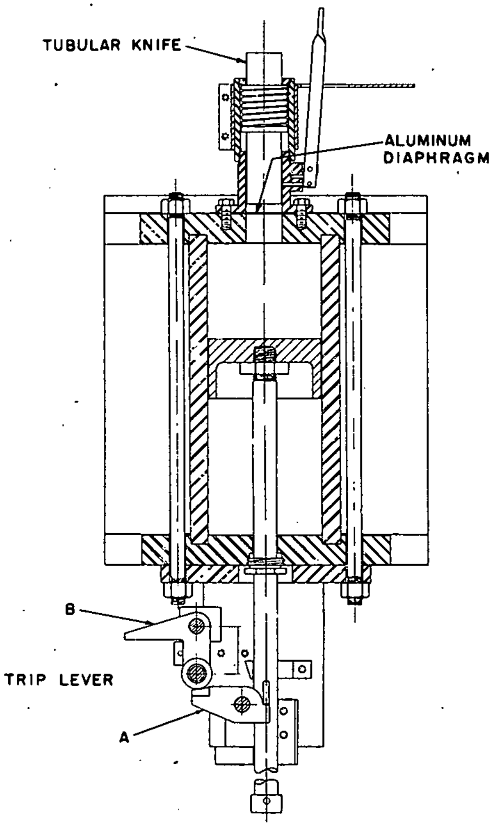
A more promising method would be the use of a rocket such as those developed during the recent war. The rocket unit itself would be light in weight; thus the inertial problem, though introduced, would not be serious. The difficulty of loading the rockets to produce the desired magnitude and duration of thrust led to the rejection of this method.

Another method considered was that of an electro-magnet. The production of rapidly increasing forces of large magnitude can be obtained by the use of large condensers which are discharged through the coil of the magnet. The core would be attached to the center of the beam being tested. However, the size of the magnetic coil and the magnitude of current needed for the production of a force of 10,000 lbs indicated that this approach was not as suitable as others.

The possibility of using springs which would be compressed and then suddenly released was also considered, but the size and consequently weight of the springs would be too great for the proper solution of the problem. In addition some method would have to be devised to end the load; no easy method was readily apparent. These two difficulties ruled out this method as a possible solution.

The most promising method considered, and that which was finally adopted, was that of a high pressure cylinder-piston arrangement. By using gas at high pressure and by utilizing duraluminum for the piston and piston rod the mass of the load system could be kept to a minimum—in fact the smallest of any of the mechanical systems considered and almost as small as the mass of the magnetic or rocket systems. Furthermore, the design could be kept very simple and the control of the pulse magnitude and duration would be relatively easy. The expansion of the gas in the cylinder would introduce modifications to the desired rectangular pulse, but there would be possibilities of securing a trapezoidal pulse as well as a nearly triangular pulse.

The method of construction of the cylinder and piston may be seen in Figure 3. This system was designed to produce a normal



LOADING MECHANISM

FIG 3

working load of 10,000 lbs, and an occasional overload of 18,000 lbs. The cylinder was made by grinding out a standard commercial steel pipe of 4.75-inch internal diameter. The end plates were made of heavy hot rolled steel.

The mass of the piston and piston rod was to be kept as small as possible to reduce the inertial effects. A high strength duraluminum casting was used for the piston, and 14 S-T duraluminum for the piston rod.

Several methods of initiating the load suddenly were considered, and a quick-acting release latch was adopted. In this method, the piston and piston rod would be restrained from applying any load to the test specimen until the release latch was tripped. Figure 3 illustrates diagrammatically the method of operation of the trip lever. In the figure, lever A holds the piston rod by a key which passes through the rod. The surface of lever A in contact with the roller on lever B was ground to the radius x to permit easy release. A hammer, which is released at the proper time by a solenoid, is used to trip lever B. By use of this system, the gas pressure may be built up to the desired amount, and the piston rod restrained from applying load until the desired moment.

Since pulses of definite duration were required, some method of ending the load had to be devised. The simplest system devised consisted of allowing all of the gas to escape from the cylinder. To do this, a 1½-inch diameter port was bored in the top plate of the cylinder, and this port covered by an aluminum diaphragm which could be punctured by a circular tubular knife. This knife is shown in Figure 3. The knife is driven by a compressed spring. It is held in the cocked position by a pin which may be withdrawn at the proper time by a solenoid.

Pressure to drive the piston is supplied by bottle nitrogen. A 3000 to 1000 lb/in^2 reducing valve and a large 500 lb/in^2 pressure gage are provided at the nitrogen bottle to permit accurate control of the pressure in the cylinder.

Figure 4 is an illustration of the completed machine, with the exception of the pressure controls, the nitrogen system, and the instruments for control and measurements which were set up in an adjoining room for convenience of operation. The base and supporting system of the Rapid Load Machine were made of concrete piers which supported a system of I beams and one wide flange beam

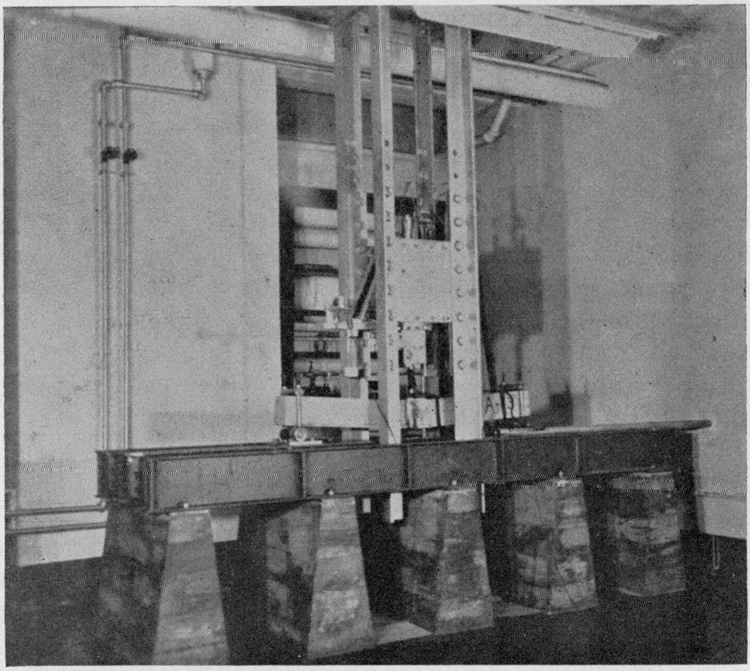


FIG. 4

which formed the bed of the machine. These members were made particularly heavy to minimize support vibrations. The vertical system used to support the cylinder-piston arrangement consisted of four angle irons. Provisions were made for raising and lowering the cylinder and piston system to accommodate different depth beams. a simple friction-plate hold was devised to provide this degree of freedom.

The machine was designed to accommodate test beams from 2 to 8 feet in length, and up to eight inches in depth.

INSTRUMENTATION

In connection with the operation of the testing machine in the experimental program, certain strain, load magnitude, and deflection measurements of the test specimen are made. Electronic, photographic, and mechanical means are used.

Load Measurement

For purposes of analysis it is important to know the magnitude of the load applied by the machine as a function of time. Of the various methods possible for the determination of this force-time curve, that of using an electric-wire strain gage seemed to be the most practical and reliable, and in addition, the easiest method to apply. Commercial Baldwin-Southwark SR-4 electric wire strain gages of type A-14 were used. They are used to measure the strain in the piston rod near the point of application of load to the beam. Measurements of strain are converted to force thus providing the desired force-time relationship. Four strain gages were cemented to the piston rod; two mounted longitudinally and two mounted circumferentially. The power supply for the bridge is a commercial audio oscillator. The signal from the bridge is recorded on a Dumont cathode ray oscilloscope and photographed with a moving film camera. The circuit diagram is shown in Figure 5.

A typical trace of the load record for one of the shorter duration loads is shown in Figure 6. The translation of this trace in to the force time curve is shown in Figure 7.

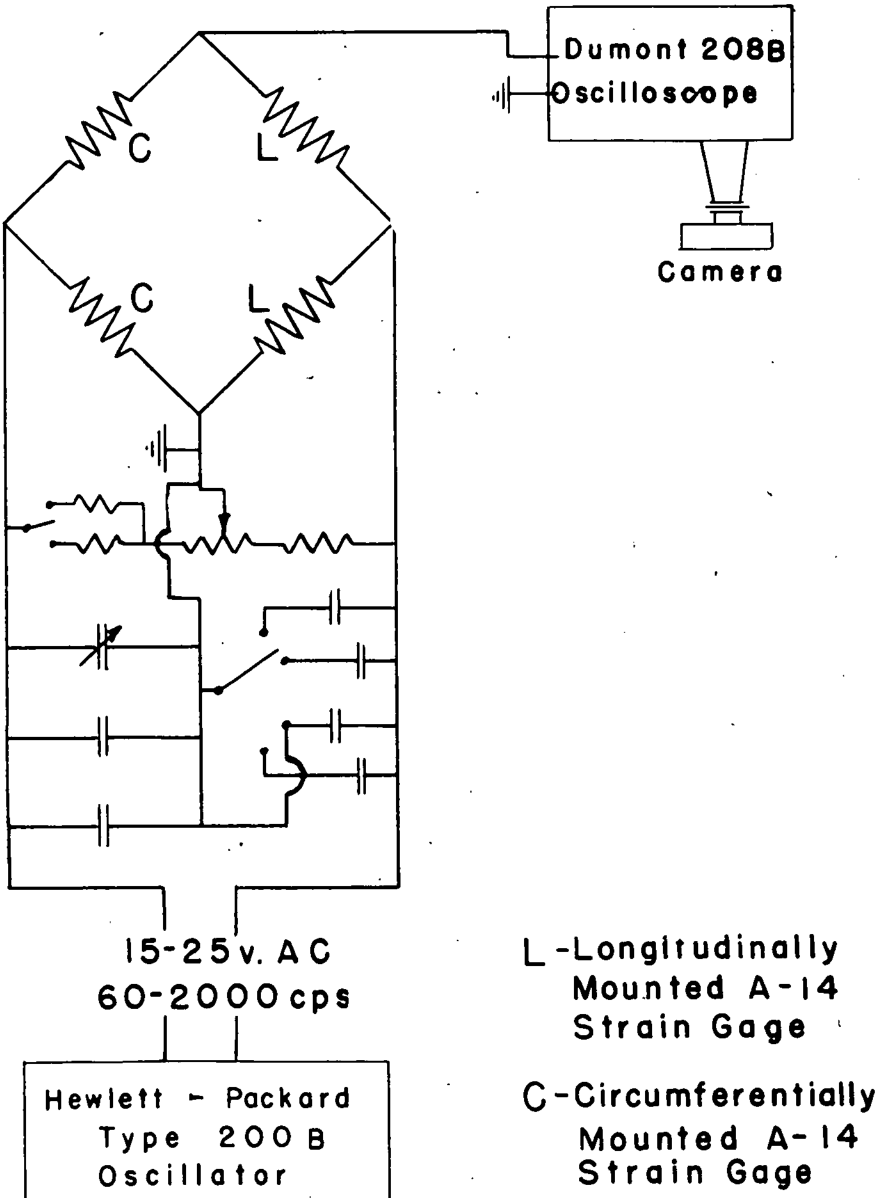
Timing of Test

The duration of the impulsive load applied to the specimens ranges from 0.01 to one second. Since a number of electrical and photographic instruments must be operated in proper sequence during the time of loading a suitable timing device must be used to control these events. The events to be controlled are:

a. initiation of the load,
b. starting the oscillograph camera,
c. starting a high-speed movie camera,
d. ending the load, and
e. stopping both cameras.

In addition, it was contemplated that another oscillograph might be added to the list of instruments to be started and stopped.

A mechanical timer was designed and constructed to control the various events. The timer consists of a 12-inch diameter disk which is driven through a reduction gear box at approximately 37.5 RPM by a small electric motor. The disk is provided with twelve concentric circular slots, six on either side of the disk. Projecting



BRIDGE CIRCUIT

FIG. 5

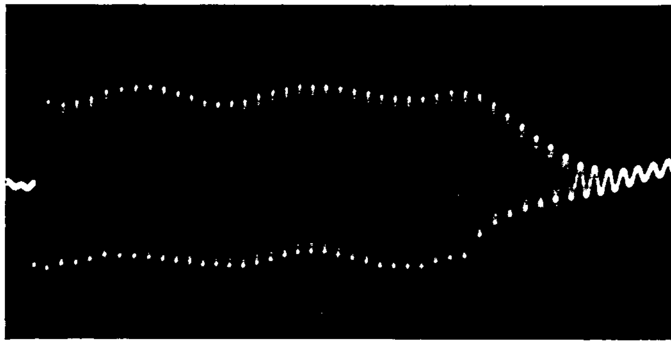


Fig. 6

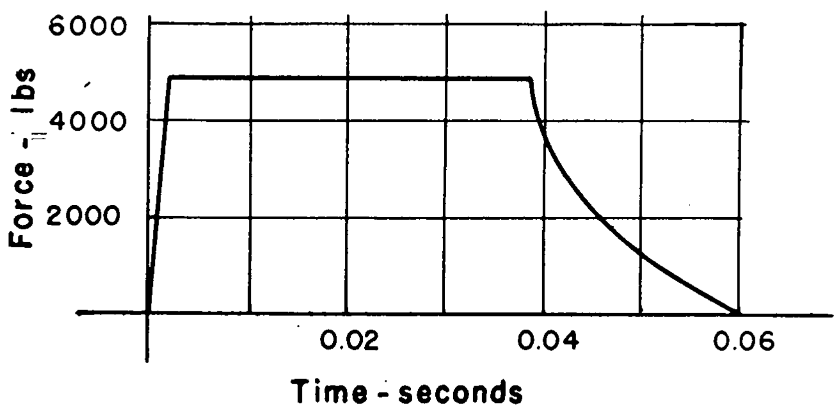


Fig. 7

lugs may be attached to the slots and moved to any circumferential position in a slot. These lugs are used to actuate switches which in turn control operation of the various camera motors and solenoids.

The timer is shown in Figure 8.

Beam Deflection and Crack Formation

Various photographic methods were considered for the measurement of deflection of the beam and for the mode of crack formation. A standard high-speed camera of the Eastman Co. was selected for use. This model of camera uses 16 mm film and will run at speeds from 1000 to 3000 frames a second. Operation is relatively simple, although special attention must be given to the lighting of the subject photographed.

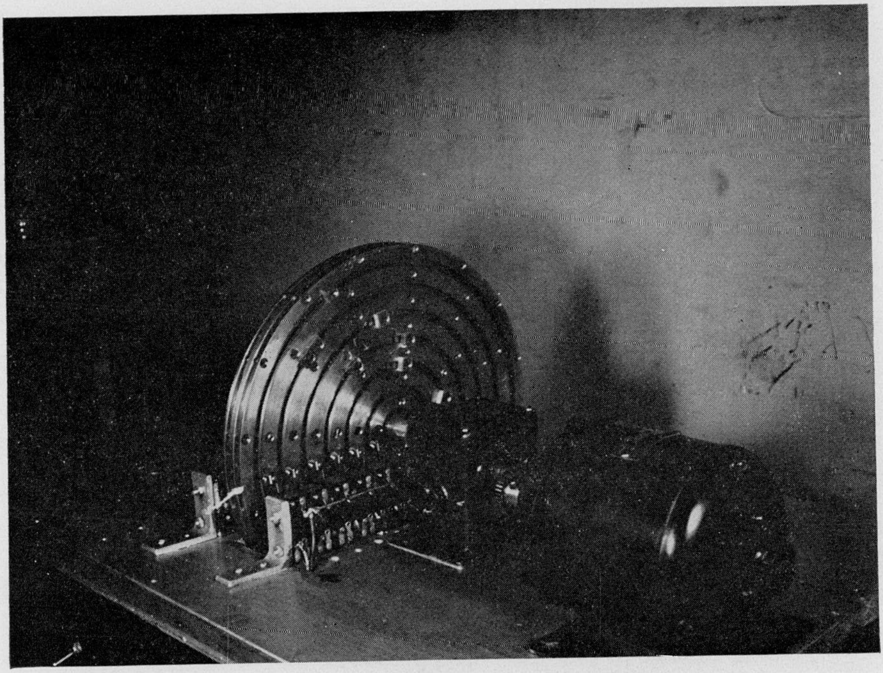


FIG. 8

A few typical frames of the moment the load is applied to the beam is shown in Figure 9. In these frames, the course of crack formation and a rough measure of the deflection of the beam as a function of time may be determined.

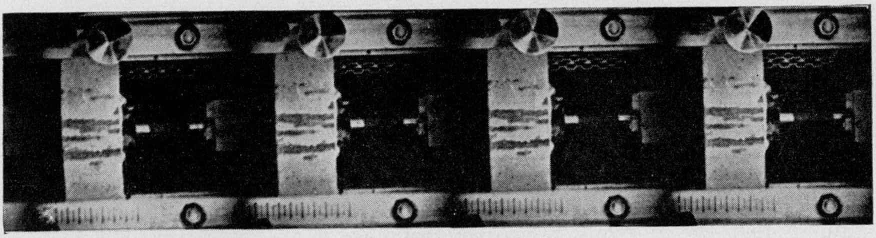


FIG. 9

Strain of Steel and Concrete

For purposes of study of the behavior of the materials in the beam, plans are being made to measure the strain of the reinforcing steel, and surface strains of the concrete. Again the electric-wire strain gage with suitable electronic circuits and oscillographs are to be used to make these dynamic measurements. To accommodate the larger number of measurements, a 6-channel Hathway oscillograph has been obtained. The preliminary investigation of methods of attaching the strain gages to the reinforcing steel is now under way.

TEST PROCEDURE

Specimens

The beam size was chosen as a compromise of the largest size that could be economically tested, and the smallest size in which reinforcing patterns and concrete mix could be made simulating full-scale structures. The result of this compromise was a beam 53 inches long (for testing on a 4-foot span), with a cross section of 4 inches width and 5¼ inches depth.

The reinforcing patterns used have been selected to produce various types of failure of the beam: i.e., failure of the tension steel, failure of the concrete in compression, and failures in shear. So far four patterns have been tested.

Beam Series	Tension steel	Compression Steel	Stirrups
A	⅜″ round	¼″ round	¼″ rd at 2½″ centers
B	"	"	4½
C	¼″	"	2¼
D	"	"	4½

Future series will include beams with much greater stirrup spacing and some with smaller compression steel.

In general two concrete compressive strengths have been used, 3000 lbs/in^2, and 6000 lbs/in^2. Each series of beams have been made in the two strengths of concrete.

Dynamic Tests

Figures 10 and 11 show a beam mounted in the Rapid Load Machine before and after being subjected to a dynamic test. In such a test the various measurements indicated above under Instrumentation are made. In addition, the total permanent deflection and the total width of cracking are recorded.

Beams have been subjected in general to two different magnitudes of dynamic loads. The first magnitude is that which will just barely crack the beam or cause a small but measureable permanent

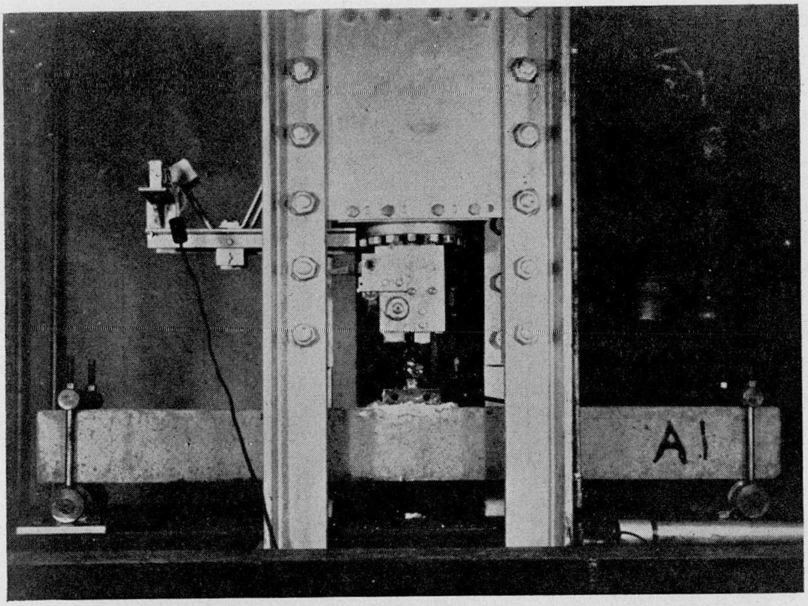


FIG. 10

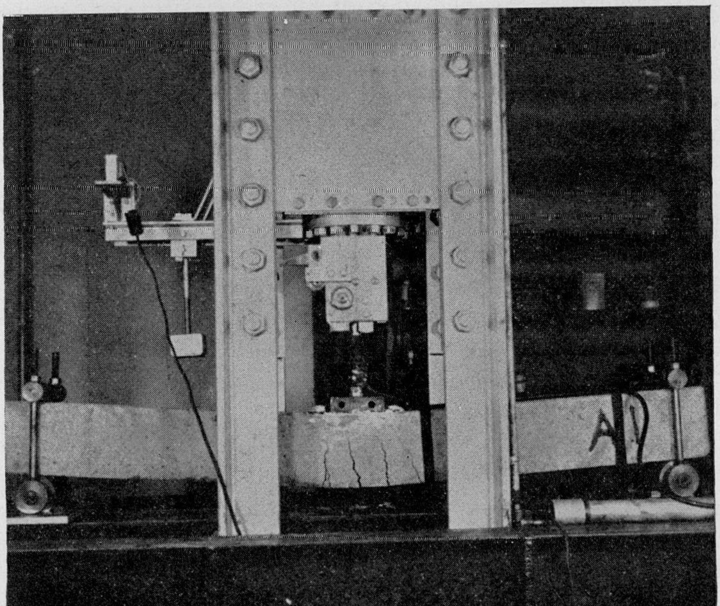


FIG. 11

deflection. Other beams in the same series have been subjected to much larger permanent deflections, of the order of 1½ inches. Attempts are made to find that load which will just cause such a condition.

Auxiliary Tests

Some of the beams of each series have been subjected to static loads in the Rapid Load Machine. Load vs deflection readings are taken for the beam up to the point of complete yield of the beam. From these curves a value for the static EI of the beam has been derived.

Auxiliary specimens are made with each beam. These include four 3 by 6 inch cylinders which are tested in compression, and one 2½ by 2½ by 10 inch beam which is used to get the sonic modulus of elasticity and then broken in flexure for a modulus of rupture value.

The large beams are also vibrated to determine the fundamental frequency. They are supported in the free-free position.

Theory

The theory of the behavior of simple elastic systems has been developed and simplified (see first reference in footnote). The exact theory is used to analyze the beams tested. In this manner the stresses in the concrete and steel are determined for those beams which are subjected to the just cracking loads.

This theory is necessarily fairly complicated and particularly tedious to apply. It is beyond the scope of the present paper to develop it.

Preliminary Experimental Results

All of the beams that have been subjected to just cracking loads have been analyzed according to the exact dynamical theory. The number of beams tested so far is so small as to preclude the drawing of any general conclusions.

The preliminary results suggest that the concrete and steel will stand stresses considerably in excess of the yield or failure stresses of the concrete and steel. In fact, the concrete in the various specimens has sustained stresses from 1.1 to 2.5 times the ultimate strength of the concrete, while the steel has sustained stresses which have ranged from 2.5 to 3.5 times the static yield stresses.

Future Tests

The program will continue along the lines outlined. Several different arrangements of steel remain to be tested. In addition, an extensive study of the strain distribution in the test beam will be made.

An important missing item of information needed for the exact analysis of the dynamical behavior of beams is the exact stress-strain relationship of the concrete under rapid rates of loading. Another research project is studying this phenomenon. When the results of this program are available, more precise values of permissible stresses for concrete and steel will be available.

OF GENERAL INTEREST

INTERSOCIETY COOPERATION FOR PROFESSIONAL RECOGNITION

BY WILLIAM F. RYAN*

The question put to me for this evening's discussion is "How can the Boston Society of Civil Engineers cooperate with the Massachusetts Society of Professional Engineers?" You can hardly be asked to cooperate with an organization you know nothing about, and obviously the first step is to explain what MSPE is, and what its aims and objectives are.

Engineers have problems. They have technical problems and professional problems. Societies like Boston Society of Civil Engineers may be thought of as organized to promote the solution of both. On the technical side the problems discussed here are primarily of interest to Civil Engineers—bridges, highways, water supplies and the like. This society is the group which, of all the people in Boston, is most interested in such matters, and most competent to discuss them. Other organizations have other technical interests. Some of these groups may include practically all of the engineers in Boston who are really vitally interested in the technical subjects they discuss.

There is every reason for the multiplicity of societies here, when we are concerned with technology, but you also have meetings like this one with no technical objective, but for a discussion of what, for lack of a better name, we may call the professional aspects of engineering.

When we come to professional problems, they are not peculiar to civil engineers, mechanical engineers, tool engineers, moving picture engineers or any other specialized branch. All of these groups, if they are professional engineers, have a common interest in this field, and the National Society of Professional Engineers, of which MSPE

*Assistant Engineering Manager, Stone & Webster Engineering Corporation is a component state society, was organized to include professional practitioners in every branch of engineering and to deal solely with professional problems.

What do we mean by "professional" problems? As an outstanding example there is the matter of professional ethics. I was appointed about three years ago to represent the American Society of Mechanical Engineers on the Committee on Ethics and Professional Practice of the Engineers' Council for Professional Development. In the course of my labors for that committee I enlisted the aid of the Ethics Committee of MSPE for an investigation of the existing status of engineering ethics. We were able to discover 41 codes of ethics promulgated by 41 different engineering societies. This was not an exhaustive investigation—just spare time work by a few busy engineers here in Boston, with no special library or other facilities for research in that field.

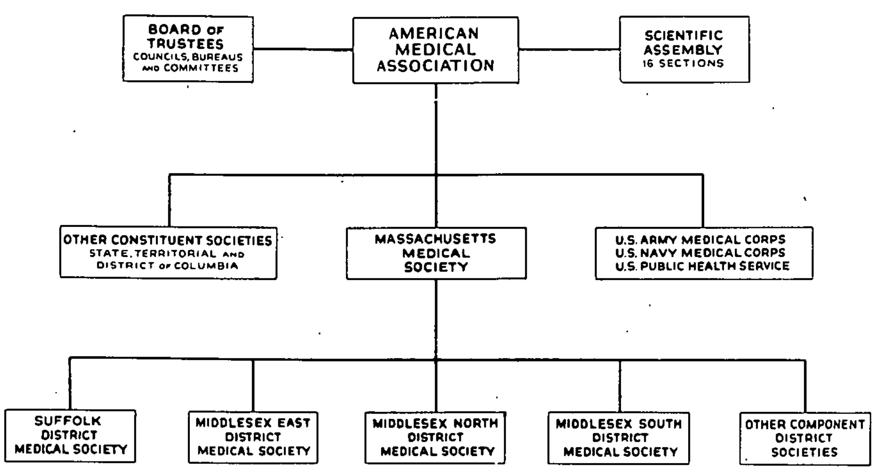
I am happy to report that after 17 years of effort, the engineering profession now has a common code of ethics. I will offer you an outstanding opportunity to cooperate not only with MSPE, but with ten major national societies, including the eight who form the Engineers' Council for Professional Development by adopting it as the code of ethics of the Boston Society of Civil Engineers. I am also taking the opportunity to present a copy of it, suitable for framing, to your society. Whether or not you decide to adopt it officially, you may be willing to display it in your library for the edification of the engineers who come here to consult your valuable works of reference.

The code is entitled "Canons of Ethics for Engineers", and it was finally ratified by ECPD at Montreal last October. Our eminent Boston engineer, Dr. D. C. Jackson, was Chairman of the Committee which presented it, and your colleague, Professor Haertlein, is a member of the Council which adopted it. As I said, I have also labored on it, and in the more laborious work of preparing the historical and philosophical background for "selling" the Canons to certain remonstrators I had the active cooperation of the Ethics Committee of MSPE, so it is a good Boston product. I hope this oldest of all American engineering societies will give it their endorsement.

There are other pressing problems of a professional nature which should be studied and acted upon in a common effort by engineers in all branches of the profession. Since they are professional problems they should be settled by professional men, not by people who merely happen to be associated in some way or another with engineering enterprises.

Professional recognition can not be achieved merely by organization. First we must be a profession, recognizing the obligations which professional status implies, and faithfully discharging these obligations. On the other hand, it is doubtful if recognition can ever be obtained without effective organization. First, to determine among ourselves what our professional obligations are; second, to enforce the observance of these obligations; and third, to convince the public, including our clients, our employers, the politicians, public administrators and business men, that we are entitled to the respect and esteem, and also the compensation which the performance of professional service deserves.

Fig. 1 is an example of an effective professional organization. This is a simplified diagram of the American Medical Association.



ORGANIZATION
OF THE
MEDICAL PROFESSION
FIG. 1

to which every doctor of the slightest professional pretensions belongs. A doctor in Boston or its suburbs belongs to the Suffolk District Medical Society or to one of the three District Societies in Middlesex County. The local Society is what he joins and where he votes; membership in the State and National Societies follows automatically. there are eighteen of these District Societies in Massachusetts, each of which is a relatively small local group, interested in common problems, and united to work together for the benefit of the public in their community and incidentally for the benefit of themselves as professional men. These several District Societies form the Massachusetts Medical Society.

Similar District Societies in the 47 other states, all the territories and the District of Columbia combine with the Massachusetts Medical Society and with representatives of the Medical Corps of the Army, Navy and Public Health Service to form the American Medical Association. Every doctor is united with every other doctor to maintain his professional interests in his own locality, in his state and in the nation.

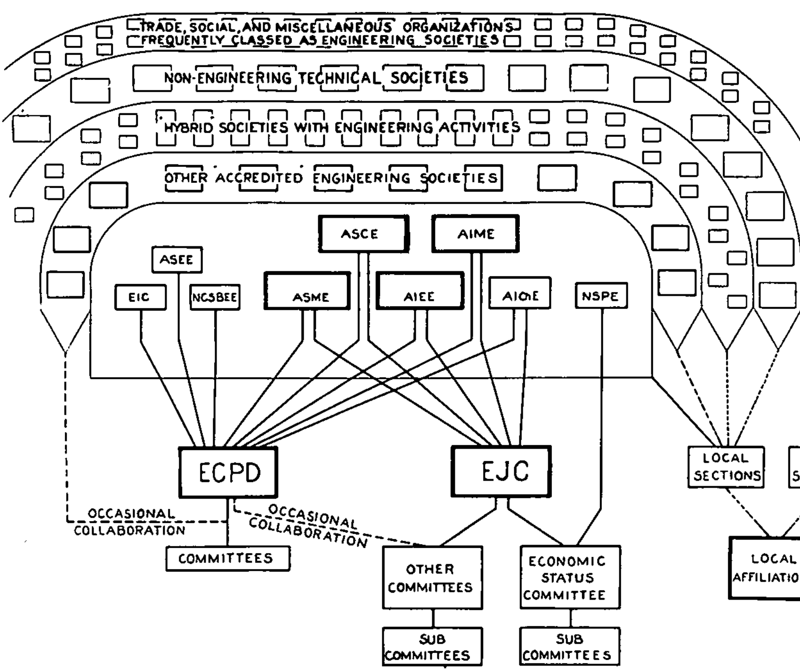
The delegates who govern the American Medical Association are elected, in numbers proportional to their membership, by the state societies, and delegates are also appointed by the Medical Corps of the Army, the Navy and the Public Health Service. The Association operates effectively through a Board of Trustees, several Bureaus and numerous Councils and Committees. Their avowed object is to protect the public in anything and everything that has a medical aspect, to oppose unwise legislation, to expose false remedies, to promote health habits, to spread medical knowledge and to establish standards of medical ethics. So far as I know, no other medical group concerns itself with such problems. This Association is organized for such purposes, and while some doctors join one society and some another for technical purposes, they all join this one, and leave to it, and to it alone, their professional and economic problems.

In this Association, they speak with one voice; they represent a united profession. This does not mean that doctors do not disagree within their own councils, but when they have reached a decision as to what is or is not in the public interest or the interest of their profession, then they present a united front. Incidental to a geniune and invaluable public service, all the more effective because of fundamentally unselfish objectives, they protect all doctors, individually and collectively, from any attack on their professional prerogatives, whether by Government, industrial or financial groups, or by individuals.

Figure 2 shows how we, as engineers, are organized to achieve our own professional objectives.

No one has been able to determine the exact number of engineering societies in this country, but there are several hundred which have "engineers" or "engineering" in their names, and many more, such as the American Welding Society or the American Society for Metals which are commonly classified as engineering societies. This diagram attempts to classify the hordes of "engineering" organizations and to chart the methods by which they attempt to promote the professional interests and economic welfare of the engineer.

As a central core, we have the four venerable Founder Societies;



PROFESSIONAL ORGANIZATION OF AMERICAN ENGINEERS

FIG. 2

American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers and American Institute of Electrical Engineers. They have taken with them a relatively young and upstart society, American Institute of Chemical Engineers, to form the Engineers' Joint Council. This group was formed originally by the presidents of the five societies to advise the State Department on the demilitarization of Germany, and they did a very effective job. However, the five presidents were acting on their own. They decided what ought to be done, and reported to the Secretary of State without referring any decisions to their respective Boards of Directors for approval.

The Engineers' Joint Council has since become a more or less permanent affair and consists of the presidents, the junior past presidents, and the secretaries of these five societies. A year or two ago they formed a rather important committee known as the Committee on the Economic Status of the Engineer and they invited the National Society of Professional Engineers to collaborate in this work. It is this committee which recently produced the volume known as "The Engineering Profession in Transition". This publication, which you can obtain for 50 cents if you are a member of any one of these six societies, or for $1 if you are not, contains voluminous statistics regarding the compensation of engineers in the United States. It is broken down by branches of engineering, by age and by education. It is the most comprehensive thing of the kind that has been done. The Economic Status Committee also sponsored a survey of employment practices which was published in most of the society journals, and a Manual on Collective Bargaining for Engineers.

These same five societies have formed another coalition with American Society of Engineering Education, Engineering Institute of Chemical Engineers and the National Council of State Boards of Engineering Examiners in what is known as the Engineers' Council for Professional Development. This is the group which approves the curricula of engineering colleges. When you apply for registration, it makes a difference whether or not you are a graduate of an "approved" curriculum. ECPD is the group which does the approving. It is also the group which formulated the "Canons of Ethics for Engineers", with assistance from the American Institute of Consulting Engineers, National Society of Professional Engineers and the National Council of State Boards of Engineering Examiners.

In addition to the nine societies in the inner group, there are others which have valid claims to professional status. I have shown them here under the label of "other accredited engineering societies". Some time ago Engineers' Joint Council, in connection with a study of engineering organization, asked Engineers' Council for Professional Development to specify which of the hundreds of engineering societies had some grade of membership which could be classed as "professional". Engineers' Council for Professional Development prepared such a list. It is not a very long list and there will be a great deal of commotion among the membership of some rather important societies if it ever is disclosed. So far, neither Engineers' Joint Council nor Engineers' Council for Professional Development has had the temerity to make the list public; each claims that it is the responsibility of the other.

In addition to the accredited societies, there are a number of "hybrid" societies with large engineering membership and with some engineering activities. This would include such organizations as American Welding Society, American Society for Metals, the Institute of Consulting Chemists and Chemical Engineers and societies of that type which have engineering activities but which include in their active membership a great many who are not engineers. Then there are nonengineering technical societies such as American Chemical Society, American Physical Society and American Mathematical Society. These also have many engineering members and they are frequently associated with engineering societies at the local level in groups such as The Worcester Engineering Society. Finally, there is the great horde of trade societies and miscellaneous organizations, including labor unions, frequently classed as "engineering societies."

Now this part of the diagram deals exclusively with national organization, for professional purposes, as distinguished from technical activities. Of the major national engineering organizations only one—Society of Automotive Engineers—has excluded professional problems from its field. That society, by action of its governing board, has declared itself to be strictly a technical organization.

Organization at the local level is even more complicated. In Los Angeles, for instance, the local Engineers' Council represents only the five societies which sponsor Engineers' Joint Council, whereas in Worcester, there are only three of these societies represented. The Worcester group includes such hybrids as The American Welding

Society and The American Society for Metals. It also includes such nonengineering groups as the Worcester Chemical Society and the Worcester Society of Architects. Now such coalitions serve a very useful purpose in opening up technical programs of each society to members of the others, but for professional objectives they are weak in their class of membership and ineffective in their ability to take definite action, particularly when a time factor is involved.

This national setup, with Engineers' Council for Professional Development and Engineers' Joint Council might be made effective so far as action is concerned if the senior societies were willing to yield their sovereignty and allow the two councils to act without referring their proposals to the various boards of direction for ratification. As an example of the clumsiness of this setup, it took exactly 17 years for Engineers' Council for Professional Development and its predecessor American Engineering Council, to formulate a code of ethics and get it ratified by a majority of the sponsor societies. I have mentioned the Manual on Collective Bargaining for Engineers, prepared by the Economic Status Committee. The volume was designed to show employed engineers how to escape being coerced into heterogeneous labor unions. If it had been issued during the early stages of engineering unionization it would have been of inestimable value, but due to the backing and filling of the various societies which had to ratify it, it was not published until a month after the Taft-Hartley Act was passed over the President's veto and it was obsolete on the date of publication.

Even if the parent societies should yield their sovereignty and entrust their representatives with full responsibility, there is a lack of direct communication between these Councils and men like yourselves in local organizations. The Boston Society of Civil Engineers has no contact with these councils. If you are also a member of American Society of Civil Engineers, you reach the Committee on the Economic Status of the Engineer only through your national society, back to the Engineers' Joint Council, and thence to the Committee. Actually, the plans are formed by a group in New York who represent you indirectly if at all, and these plans are eventually ratified or rejected by other groups who represent you more directly, but nevertheless remotely.

Figure 3 shows the organization of NSPE, closely paralleling the American Medical Association, and having parallel objectives.

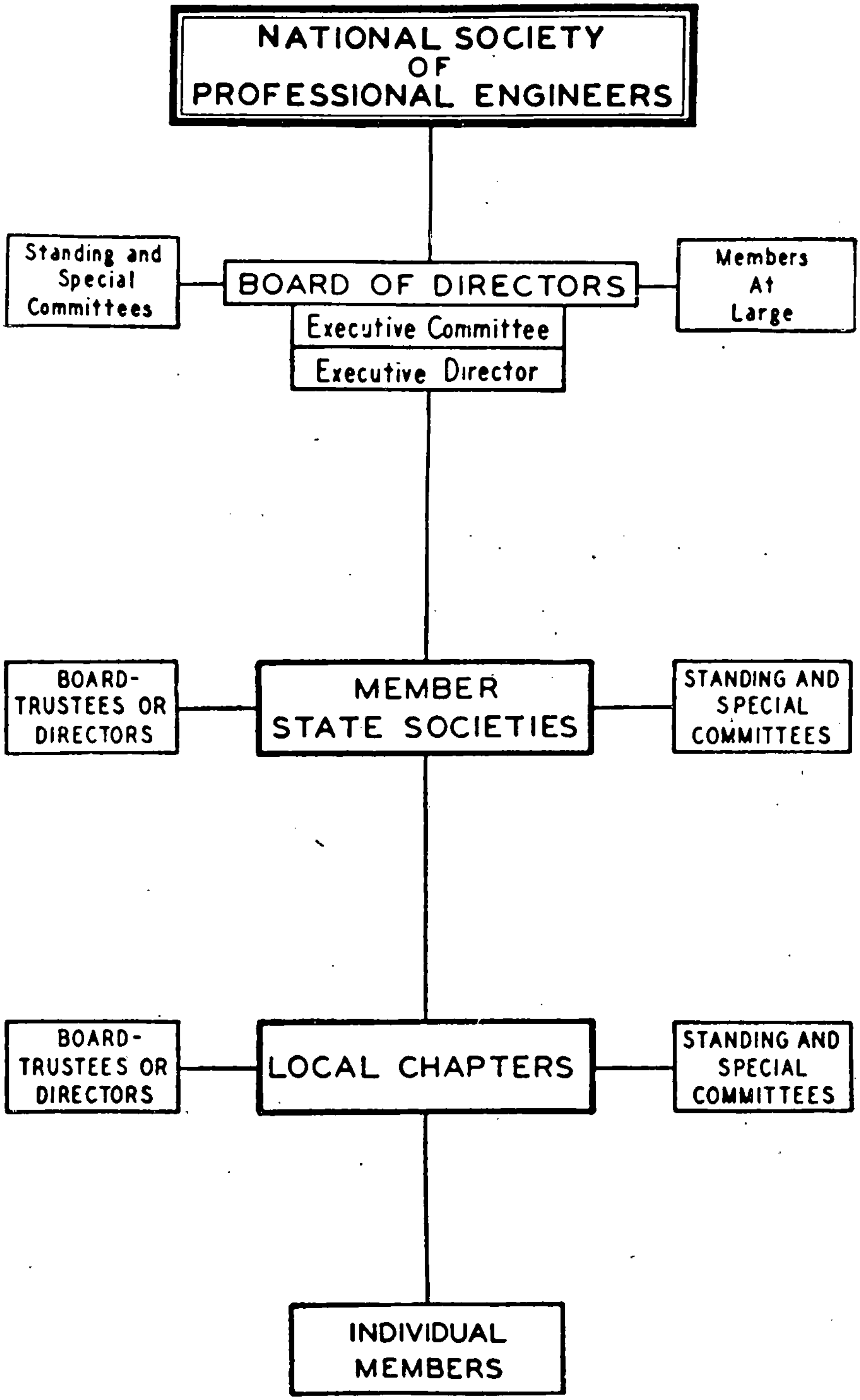

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS
Standing and Special Committees
BOARD OF DIRECTORS
Executive Committee
Executive Director
Members At Large
BOARD-TRUSTEES OR DIRECTORS
MEMBER STATE SOCIETIES
STANDING AND SPECIAL COMMITTEES
BOARD-TRUSTEES OR DIRECTORS
LOCAL CHAPTERS
STANDING AND SPECIAL COMMITTEES
INDIVIDUAL MEMBERS

FIG. 3

This society has only one criterion for membership—registration or licensure as a professional enigneer by some state or territory of the United States. Every member therefore has legal certification of his qualifications. No claim is made that registration is the only proof of professional status. However, it is the simplest proof, and certainly the most conclusive proof in courts of law.

In this organization, one joins the state unit, is assigned to a local chapter, when all of the problems are discussed in New England term meeting fashion, and automatically becomes a member of the national society where the conclusions of groups in Boston, Akron, Atlanta and all of the industrial centers of the United States are coordinated and crystallized for united action. It is a rapidly growing society, having over 17,000 members the rest of this year, but to fulfill its destiny it should include every professional engineer.

How can you cooperate with this society?

The best way is to join it, if you are eligible. You are eligible, of course, if you are registered as a professional engineer in any of the 48 states. If you are not registered, apply for registration. Every qualified engineer owes himself that much self-recognition at least.

If you do not wish to join the society, you can still cooperate effectively by attending the open meetings of the Metropolitan Chapter and joining in the discussions. The object of the local groups is to thrash out thoroughly the problems of the engineer at the local level, to crystallize ideas, and transmit considered conclusions to the state and national organizations for action; we should be glad to have the viewpoint of any BSCE member in any of these deliberations.

One problem before us now, in which we seek your cooperation, has to do with our state registration law. MSPE plans, when the time is opportune, to propose a modification of the present law. By "when the time is opportune" I mean when men like you, throughout the state, are in agreement with us, and will support the proposed amendment. I am confident that such an agreement will be reached when you understand what we hope to accomplish.

The sole object of the proposed amendments is to bring the Massachusetts law into conformity with the so-called "Model Law", so far as the Constitution of our Commonwealth permits.

The Model Registration Law is the product of 40 years of study and development. In its present form it has the official approval and endorsement of all of the 13 major engineering societies who collaborated in drafting this recommended legislation. These are:

American Society of Civil Engineers
American Society of Mechanical Engineers
American Association of Engineers
American Institute of Consulting Engineers
National Society of Professional Engineers
National Council of State Boards of Engineering Examiners
American Institute of Electrical Engineers
American Society of Heating and Ventilating Engineers
American Institute of Mining and Metallurgical Engineers
Illuminating Engineering Society
Society of Naval Architects and Marine Engineers
American Institute of Chemical Engineers
American Society of Engineering Education

The objective of these societies is to achieve uniformity of the laws in the 48 states, since a Federal law is impossible under the U. S. Constitution. The Model Law is designed to provide adequate protection for the public and professional recognition of the engineer, yet prevent unreasonable restrictions which have crept into the laws of some states. Unfortunately a number of states, including Massachusetts, have passed legislation which does not conform to the Model Law. Several states have laws which are unreasonably restrictive, handicapping practice by Massachusetts engineers in those states, and creating an obstacle to the acceptance of employment, in responsible positions, by Massachusetts men who might wish to move within their borders. The most constructive step which we in Massachusetts can take to oppose such interstate barriers is to bring our own legislation into conformity with the Model law. This is the first object of the proposed amendments.

A detailed study will show that every feature of the Model Law is well considered, and it is the best basis on which reasonable uniformity and reciprocity can be obtained throughout the 48 states. The principal changes required to achieve this conformity are: Formal recognition of the Engineer-in-Training, more definite provisions for reciprocity with other states, and mandatory, rather than permissive registration for engineers in responsible charge of important engineering work.

The Model Law officially recognizes the young man with an engineering degree who has not yet had sufficient experience to qualify for registration; it gives him an immediate status in the engineering profession at a time when he is particularly vulnerable to proselyting by labor unions and others who would be glad to purchase his birthright. The Model Law provides for reciprocal relations between states which have equal registration requirements, on a fair and reasonable basis which all states should be willing to accept.

It has been objected that adoption of the Model Law, and its mandatory provisions, would necessitate restoring the "Grandfather Clause" which expired here in January 1947. It should be remembered that there is nothing in the present law to prevent anyone, resident or not resident, from practicing engineering in this state. A mandatory law may recognize the existing "grandfathers" for their respective lifetimes, but under the present law the practice of engineering by unqualified men may be perpetual.

Of the six states which originally had permissive laws, four have been amended to conform to the Model Law, and in no case was the "Grandfather Clause" reinstated for more than one year. Of the 51 registration laws in 48 states and 3 territories of the United States, only Massachusetts and New Hampshire have retained the permissive measure.

While the present Massachusetts law undoubtedly represented the best thought of local engineers when the legislation was proposed, the time is at hand when we should reconsider the matter and accept the recommendations of the major engineering societies as proposed in the Model Law.

In conclusion, it should be obvious that there are many opportunities for cooperation between BSCE to cooperate with MSPE, individually and collectively, and I can assure you for MSPE that such cooperation will be warmly appreciated.

EVENING ENGINEERING COURSES IN THE GREATER BOSTON AREA

By William C. White*

Boston affords a very wide variety of opportunities for formal study through evening classes, not only in technological fields but in many others as well. The 1947-48 catalog of the Prospect Union Educational Exchange—a philanthropic agency with headquarters in Cambridge which provides impartial reports on educational opportunities for adults—lists over 200 schools offering some 4000 different courses in several hundred fields ranging all the way from accounting to zoology. Thirteen of the catalog pages are given over to the listing of courses within the broad field of engineering, these courses being mostly of the technical institute type.

The Sub-Committee on Curricula of Technical Institute Type appointed by Engineers' Council for Professional Development defines such programs as follows:

"1. The purpose is to prepare individuals for various technical positions or lines of activity encompassed within the field of engineering, but the scope of the programs is more limited than that required to prepare a person for a career as a professional engineer.

"2. Curricula are essentially technological in nature, based upon principles of science, require the use of mathematics beyond high school, and emphasize rational processes rather than rules of practice.

"3. Programs of instruction are briefer, and usually more completely technical in content than professional curricula, though they are concerned with the same general fields of industry and engineering. They do not lead to the baccalaureate degree in engineering. Such designations as Engineering Aid, Technical Aid, Associate in Engineering, and Engineering Associate are appropriate designations to be con-

*Director of Day Colleges, Northeastern University, Boston, Mass.

ferred upon the graduates of programs of technical institute type.

"4. Training for artisanship is not included within the scope of education of technical institute type."

The principal agencies in Greater Boston now offering evening courses in engineering of technical institute type are the following:

LOWELL INSTITUTE SCHOOL. Financed by the Lowell Foundation and using the facilities of M. I. T., the School offers two year evening curricula in mechanical, electrical, and structural technology and certain supplementary courses in fields such as applied mathematics, electronics, applications of electricity in industry, principles of radio communications, heat treatment, engineering vibrations, and advanced testing materials laboratory.

Originally the School was designed to meet the educational needs of industrial foremen, but it now enrols many young machinists, draftsmen, and apprentices. Total enrolment, including post graduate students in the supplementary courses, is about 450.

LINCOLN INSTITUTE. Operated as an affiliate of Northeastern University, Lincoln Institute currently enrols about 1800 students in four year evening curricula leading to the degree of Associate in Engineering. Students may major in chemistry, civil and structural engineering, electrical engineering, mechanical engineering, or industrial engineering. The work is of college grade but briefer in scope than that of the typical program leading to a baccalaureate degree in engineering. Admission requirements are less stringent. Attention is focussed upon technological courses that will be of direct benefit to the student in the engineering work upon which he is employed during the day and time does not permit including in the curricula the usual sequence of humanistic-social courses that are usually found in engineering programs.

WENTWORTH INSTITUTE. A privately endowed technical institute, Wentworth offers a variety of evening programs ranging in duration from one to two years. Machine work, Mechanical Drawing and Machine Design, Electrical Installation, Refrigeration, Air-Conditioning, Applied Electricity and Electrical Machinery, Welding, Architectural Drawing and Design, Machinery Pattern Making, Plan Reading and Estimating, are some of the fields covered. The courses are taught by regular members of the Wentworth Institute faculty and serve an enrolment of about 500 students.

FRANKLIN TECHNICAL INSTITUTE. Originally endowed by Benjamin Franklin, the Institute now serves some 1550 evening students in a variety of technical fields including Automobile electricity, Automobile Engines, Mechanical Theory and Design, Structural Theory and Design, Machine Drafting, Sheet Metal Drafting, Electrical Machinery, Industrial Electronics, Electric Wiring, Industrial Chemistry, Metallography, Estimating, Architectural Plan Reading, Plumbing Science and Design, and Photography. The teaching staff includes many well qualified men from industry as well as the full time members of the Institute's faculty.

MASSACHUSETTS DEPARTMENT OF UNIVERSITY EXTENSION. The Department of Education in the Commonwealth through its Division of University Extension, offers many courses within the broad field of engineering. Some 8000 people are enrolled during the present year in such courses as Theory of Complex Functions, Matrix Algebra, Transients in Linear Systems, Structural Analysis, Production Control, Architectural Drawing and Drafting Room Practice, Diesel Engines, Industrial Electricity, Metallography and Heat Treatment, Radio, and many others. Classes meet at Harvard, M. I. T., Boston Public Schools, and similar places in Greater Boston. A variety of home study courses in engineering and industrial subjects are also sponsored by the Department.

In general the opportunities for evening study in the field of engineering in this area are designed to prepare people for sub-professional or semi-professional positions such as drafting, computing, inspecting, etc. There are few, if any, engineering courses offered at the graduate level in the evening in Greater Boston.

The Committee on Engineering Education and Professional Development of the Engineering Societies of New England, under the very able leadership of Professor Frederick Weaver of Tufts College, has done a great deal during the past two years to stimulate thinking about the needs of professional employees for evening courses that would enhance their effectiveness as engineers. A preliminary survey conducted by the Committee indicated that there was a real demand for such courses also for evening curricula leading to the bachelor's and the master's degree in engineering.

Unfortunately the engineering colleges are so heavily loaded with peak enrolments and research activities in the early postwar period that they are unable to serve this additional clientele at the moment, although the deans of the four engineering institutions located in Greater Boston are very desirous of doing so as soon as possible.

Under the auspices of Professor Weaver's Committee a careful study is now being carried on by a graduate student to discover exactly what fields of study would be of greatest interest to professional engineers and how the work can best be organized, with the hope that a start can be made next fall.

The Committee has studied the evening curricula leading to the bachelor's degree in engineering given at Cooper Union, New York University, College of the City of New York, Polytechnic Institute of Brooklyn, and Carnegie Institute of Technology. These programs range from six to nine years in duration with a tendency toward an eight year period. Students attend classes for three or four nights a week and much of the material that will be of immediate use to them in their daily employment is not reached until the third year.

In view of the fact that enrolments in regular engineering schools have more than doubled over the pre-war peak* that was reached in 1924-43 it seems unnecessary to establish evening undergraduate curricula in order to provide more engineers, although such programs may be desirable for other reasons. A more immediate need would seem to be the establishment of evening courses that would enable men who already have their baccalaureate degrees to advance their knowledge and skill as professional engineers. Evening courses at the graduate level are likely a more pressing need than evening undergraduate curricula in engineering.

The E. S. N. E. Committee plans to confer with the deans of engineering at Harvard, M. I. T., Tufts, and Northeastern when the results of the study now being carried on are available and hopes in the near future to make arrangements for a series of courses that will serve the needs of engineers who are working in the Greater Boston Area.

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*Enrolment in engineering schools in 1947-48 is about 250,000.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

APRIL 21, 1948.—The Centennial Anniversary Banquet and Dance of the Boston Society of Civil Engineers was held this date at the Hotel Continental, Cambridge, Mass. Dinner was served at 7:00 P.M.

President Weaver called the meeting to order at 8:00 P.M., and announced that this was the 2nd part of the Centennial Anniversary celebration of the Society.

President Weaver announced that Honorary Membership in the Society had been conferred on one of the Society's distinguished members, by vote of the Board of Government on March 24, 1948, to Mr. Sanford E. Thompson who became a member on June 12, 1895.

Mr. Miles N. Clair introduced Mr. Sanford E. Thompson and presentation of the certificate of Honorary Membership was made by President Weaver.

The certificate read as follows:

BOSTON SOCIETY OF CIVIL ENGINEERS

In recognition of his eminence in civil and mechanical engineering, especially in industrial management and marketing

SANFORD ELEAZER THOMPSON

has been duly elected an

HONORARY MEMBER

By direction of the Board of Government

March 24, 1948

(Seal)

HARVEY B. KINNISON
President

EDWIN B. COBB.
Secretary

President Weaver then introduced the speaker of the evening, Dr. Carl S. Ell, President of Northeastern University who gave a most interesting talk on "Looking Ahead".

At the close of the meeting members and guests enjoyed dancing and a social get together.

102 members and guests attended this meeting.

ROBERT W. MOIR, *Secretary*

MAY 19, 1948.—A meeting of the Boston Society of Civil Engineers was held this date at the American Academy of Arts & Sciences, 28 Newbury Street, Boston, Mass.

President Weaver called the meeting to order at 7:10 P.M., and announced the death of Mark E. Kelley who was elected a member September 21, 1910 and who died February 2, 1948.

The secretary announced that at a meeting of the Board of Government held May 17, 1948, 62 new members were elected, 3 were transferred from grade of Junior to Member, 3 were transferred from grade of Student to Member, 3 were elected to grade of Junior and 24 were transferred from grade of Student to grade of Junior.

President Weaver then introduced the speaker Mr. Charles B. Spencer, Vice-President of Spencer, White and Prentis, Inc., of New York, who gave a talk on the "Construction of the

6th Avenue Subway in New York City". The talk was illustrated by motion pictures.

After a short discussion the meeting adjourned to the lounge where a collation was served.

112 members and guests attended the meeting.

ROBERT W. MOIR, *Secretary*

STRUCTURAL SECTION

MAY 12, 1948.—The meeting was called to order at 7:20 P.M., by Chairman Oliver G. Julian, after a dinner at the Smorgasbord at which 26 attended.

The minutes of the last meeting were read and accepted.

Mr. Frank A. Cundari of the Old Colony Construction Company gave a paper on "Estimating Building Construction Costs including development of Unit Prices". He took the view point of an estimator in making bids and stated the first thing to do was to list every item in the specifications. This would serve as a check to see that no item was left out of the estimate and also make a list for obtaining sub bids and also be able to analyze the sub bids to see that they conform to the specifications. Mr. Cundari mentioned various items and a few kinds. Among them were: in excavation for footings take as an area the neat lines plus ½ the depth as an allowance for working room and slope of material.

A few items next discussed were cleaning of site, protection of trees, disposal of caisson excavation, backfilling, wood and steel sheeting and pumping. He advised taking concrete and forms off at the same time and to add the make up of column forms at the story where height was increased. Floor forms, wall forms and walls above floors are to be taken separate. He also stated that coping forms were to be taken on a lin. ft. basis and stair forms on a lin. ft. of riser.

Mr. Cundari said that masonary was one of the major items and he used the method of taking the sq. ft. area of each thickness of the various wall materials. Stone work was on a cu. ft. basis and also determine the weights of stones to be handled in order to choose the equipment needed to hoist and set. Various types of scaffolding were mentioned.

The next items discussed were cement finishes and surface treatments, floor hardeners and protection. In discussing structural lumber he listed these in items of relative difficulty of erection such as floor timbers, floor joists, spiking pieces, boarding, stud partitions, wall strapping hung ceilings and ceiling fuming. Allowance must be made for waste in lengths to next larger even foot and also dressing and matching. Plaster grounds and finish carpentry need to be listed in detail as it was sometimes an expensive item.

Some items to watch out for were listed as a 30% shrinkage in cinder fill, repair of streets, joining new work to old, expansion joints, permits, fire insurance, Job office, watchman, water, temporary heat, temporary light, enclosures, lines and grades. He said that supervision should be figured on the time of construction rather than a percentage of the labor.

An extended discussion period followed. The meeting adjourned at 9:30 P.M.

There were 64 members and guests present.

ARTHUR E. HARDING, *Clerk*

APPLICATIONS FOR MEMBERSHIP

[July 1, 1948]

The By-Laws provided that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admisson and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

RALPH S. ARCHIBALD, Melrose, Mass. (b. May 6, 1924, Malden, Mass.) Attended Tufts College School of Engineering partly under the Naval R. O. T. C. program and was graduated with the degree of B.S. in Civil Engineering Summa Cum Laude in June 1945. Commissioned at the same time I served on active duty with the U. S. Navy at sea until July 1946. In September, 1946, entered the Harvard Graduate School of Engineering and graduated in June 1947 with the degree of M.S. in Sanitary Engineering. Was awarded the Clemens Herschel Prize in Hydraulics for that year by Harvard University. Immediately became engaged by the firm of Hayden, Harding and Buchanan as a Sanitary Engineer and have been employed there ever since in the design of sewage treatment plants, sewerage systems and hydraulic problems pertinent to such work. Some design of concrete and other structural materials has also been done by me during this period. Refers to *H. P. Burden, G. M. Fair, H. W. Legro, A. P. Rice, H. A. Thomas, Jr.*

STUART M. ALEXANDER, Denver, Colorado. (b. January 28, 1945. Utica, New York). Attended the School of Technology of the City College of New York 1942-1945. Received BCE degree in 1945. Experience, 1945-46 employed as Junior Engineer by Oklahoma State Highway Commission in roadway design division; 1946-47 with U. S. Bureau of Reclamation as a junior engineer on The Earth Dams Section, Dams Division on earth materials control and special studies; 1947 with R. J. Tipton & Assoc. Inc., Engineers of Denver, Colorado, on special study; from September, 1947, to June, 1948, graduate student in Soil Mechanics at Harvard University. Received M.S. in June, 1948. At present employed by R. J. Tipton & Assoc., Inc., on Special Study. Refers to *A. Casagrande, A. Haertlein, W. L. Shannon, S. D. Wilson.*

HENRY R. DICICCO, Boston, Mass. (b August 29, 1914, Boston, Mass.) Graduated Boston English High School in 1932. Entered Tufts College of Engineering and attended during the years 1933-1936. Majored in Civil Engineering. In March 1941 was inducted in the service of the U. S. Army. Served as a private in the Pacific Theatre until May 1944 and attended Officer's Candidate School and commissioned 2nd Lieutenant. Discharged in October 1945. Experience, 1936-1941 employed by Joseph DiCicco & Company, contractors, work consisted of estimating cost of labor and materials in sewer and water pipe laying contracts. 1946-47 entered Lincoln Techncal Institute of Northeastern University and expect to receive a degree in Civil Engineering in May 1948. At present am employed by the Metropolitan Transit Authority in the Engineering Division of the Maintenance Department as draftsman. Refers to *A. J. Blackburn, G. W. Hankinson, E. B. Myott, A. McVarish, E. L. Spencer.*

JOHN R. HARTLEY, Barrington, R. I. (b. October 10, 1910, Fall River, Mass.) Graduated from Rogers High School, Newport, R. I., in 1929; August 1929 became apprentice draftsman with Builders Iron Foundry. During this period attended special extension classes at Brown University in Machine Design, Mechanical Engineering, and Electrical Engineering; February 1935, became a sales engineer, assisting consulting engineers and others in the design and application of all kinds of metering and controlling apparatus, principally for water and sewage works. In this work, it is necessary to have knowledge of current practice and to keep abreast of new developments, not only in instrumentation, but also in the broad field of water and sewage plant design. Since 1941 have been Assistant Sales Manager for Builders Providence, Inc., on water and sewage works equipment. Refers to *A. J. Burdoin, H. G. Dresser, F. L. Flood, S. Keith, W. H. Sears.*

JAMES J. KENNEY, JR., Quincy, Mass. (b. January 17, 1915, Boston, Mass.) Graduate of Cathedral High School in 1932; Attended Boston College 1932-1933, Boston University evenings 1933-34-35-36; M. I. T. evenings 1940-41-42 (Lowell School) also special courses in "reinforced concrete" moment distribution and soil mechanics. Experience, 1936-1938 general draftsman and surveyor with T. B. Kenney C. E; 1938-1940 Geodetic Survey and Computer with City Planning Board; 1940-46 Bethlehem Steel Company as assistant to Civil Engineer engaged in design and supervision of construction of docks, shipways, buildings, heavy, lifting equipment and gangways or other things connected with maintenance of the plant; 1946-47, E. B. Badger & Sons Company as structural designer; 1947-48, Fay, Spofford & Thorndike as structural designer and in March 1948 returned to E. B. Badger & Sons Company as structural designer. Since June, 1947, also have been associated with Ralph L. Rankin, Architectural and Structural Engineer. Refers to *R. E. Crawford, G. Douglas, K. Krawcyk, R. L. Rankin, H. M. Mellish.*

ERNEST A. MYERS, Wakefield, Mass. (b. March 14, 1903, Milford, Mass.) Attended Northeastern University 1922-23; 1923-24; Lowell Institute 1924-25. Experience, with Stone and Webster Engineering Corporation 1923, 1924-1931; City of Boston Park Department 1932-1933; Metropolitan District Water Supply Commission 1933-1941; Shreve Lamb and Harmon, Fay, Spofford and Thorndike, 1941-1943; 1943 to date Metropolitan District Water Supply Commission—Metropolitan District Commission. Construction Division as Assistant Civil Engineer. Refers to *C. J. Ginder, L. M. Gentleman, K. R. Kennison, M H. Mellish.*

RUTH D. TERZAGHI, Winchester, Mass. (b. October 14, 1903, Chicago, Ill.) B.S. 1924, M.S. 1925, University of Chicago, Ph.D. 1930, Radcliffe. Experience, 1925-26, instructor in Geology, Goucher College; 1926-28 Instructor in Geology, Wellesley College; 1930-43, Research on problems of geology and engineering geology; co-operation with Karl Terzaghi on examination of dam sites; 1943 to date, Concrete research. Consultant, Association of American Railroads. Refers to *A. Casagrande, A. Haertlein, H. M. Turner, K. Terzaghi.*

HENRY E. WILSON, Boston, Mass. (b. August 1, 1896, Ipswich, Mass.) Graduated from Massachusetts Institute of Technology in 1919, B.S. in Civil Engineering; Harvard University class of 1919, B.S. in Civil Engineering (owing to War Class was graduated in September, 1918) Experience served briefly with the Army Engineers at Camp Humphries, Va. Worked for Bethlehem Steel Bridge Corporation at Steeltown, Pa., on structural Steel drafting, design, and field engineering until April 1921 when I took a professional examination and entered the Corps of Civil Engineers, U. S. Navy as a Lieutenant (jg), advanced to rank of Captain which I now hold. Service of 27 years in the Navy has included the design and construction of practically all types of facility used by the Naval Shore establishment, including complete shipyards; lighter-than-air bases; air fields (heavier than air); ammunition depots; advance bases; training stations; receiving stations; power plants; hospitals; shipyard facilities of all types such as drydocks, piers, wharves, industrial plants of all kinds; warehouses; pavements; sewage systems, etc. Among the latest engineering structures of note with which I have been identified was a vertical lift type high level 6 lane steel highway bridge at the Naval Base, Terminal Island, California. At present District Civil Engineer and District Public Works Officer of the First Naval District. Duties of this position involve inspection and general supervision over the engineering features of all Naval Shore Establishments in the New England Area. Also involves direct supervision and control of all construction in the District not specifically assigned to some Base or Shipyard or other component of the Navy. Refers to *T. A. Berrigan, M. N. Clair, A. B. Edwards, A. Haertlein.*

Transfer form Grade of Junior

CLARENCE R. WICKERSON, Winchester, Mass. (b. November 10, 1902, Eastport, Maine.) Graduate from Northeastern University in 1926, B. C. E. Completed a structural Design and Detail course at Tufts College in 1941. Experience, with Whitman & Howard, Inc., as engineer since 1926. At present date active on water-works projects. Refers to *C. Howard, P. F. Howard, C. R. Pearson, L. M. Pittendreigh.*

Transfer from Grade of Student

DAVID A. DUNCAN, Dorchester, Mass. (b. September 30, 1923, Dorchester, Mass.) Northeastern University (September, 1941—April, 1943; July, 1946—June, 1948) B.D. In Civil Engineering. Experience, July, 1947—September, 1947 and from March 1948 to present time with Metcalf & Eddy, Engineers, Boston, Mass., inspection, designing and drafting. Refers to *C. O. Baird, E. A. Gramstorff, G. W. Hankinson, E. L. Spencer.*

ROBERT D. KEEGAN, Dedham, Mass. (b. September 7, 1927, Boston, Mass.) Graduated from Dedham High School in 1944. Attended Northeastern University from September 1944 until present and expect to graduate in June 1948 with a degree of B.S. in Civil Engineering. Refers to *C. O. Baird, E. A. Gramstorff, G. W. Hankinson, E. L. Spencer.*

RICHARD E. SPRAGUE Quincy, Mass. (b. June 9, 1922, Quincy, Mass.) Northeastern University September, 1940 to June, 1943; Civil Engineering Student at Tufts College Navy V-12 program July, 1943 to June 1944. Served from September, 1944 to July, 1946 as commissioned officer in Civil Engineer Corps of U. S. Naval Reserve, including 18 months overseas in base maintenance with U. S. Naval Construction Battalions. September 1946 to July, 1947, Northeastern University. Received B.S. degree in Civil Engineering from Northeastern University in September 1947. At present studying achitectural design at evening school of Boston Architectural Center. Since October, 1947, employed as a detail draftsman with some design in reinforced concrete by Bethlehem Steel Company, Cambridge, Mass. Refers to *C. O. Baird, E. A. Gramstorff, E. M. Howard, C. R. Pearson.*

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DEATHS

Mark E. Kelley, February 2, 1948.
C. Frank Allen, June 6, 1948.

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The advertising pages of the JOURNAL aim to acquaint readers with Professional and Contracting Services and Sources of Various Supplies and Materials. You would find it of advantage to be represented here.

Volume XXXV JULY, 1948 Number 3

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

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1848
BOSTON
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CENTENNIAL ANNIVERSARY
1848-1948

JULY - 1948

VOLUME XXXV
TWO SECTIONS

NUMBER 3
SECTION 2

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CENTENNIAL ANNIVERSARY PROGRAM

BOSTON SOCIETY OF CIVIL ENGINEERS

Founded July 3, 1848

100th Anniversary Meeting—March 31, 1948

Annual Reports and Election of Officers

Presidential Address by Harvey B. Kinnison

Annual Dinner and Presentation of Prizes

Centennial Symposium—

Contributions of the Members of America's Oldest Engineering Society to 100 Years of Progress in Civil Engineering

Transportation—By Prof. Charles B. Breed

Sanitary Engineering—By Dean Gordon M. Fair

Structural Engineering—By Prof. Charles M. Spofford

Hydraulics—By Prof. Howard M. Turner

Banquet and Dance—April 21, 1948

Centennial Address—"LOOKING AHEAD"

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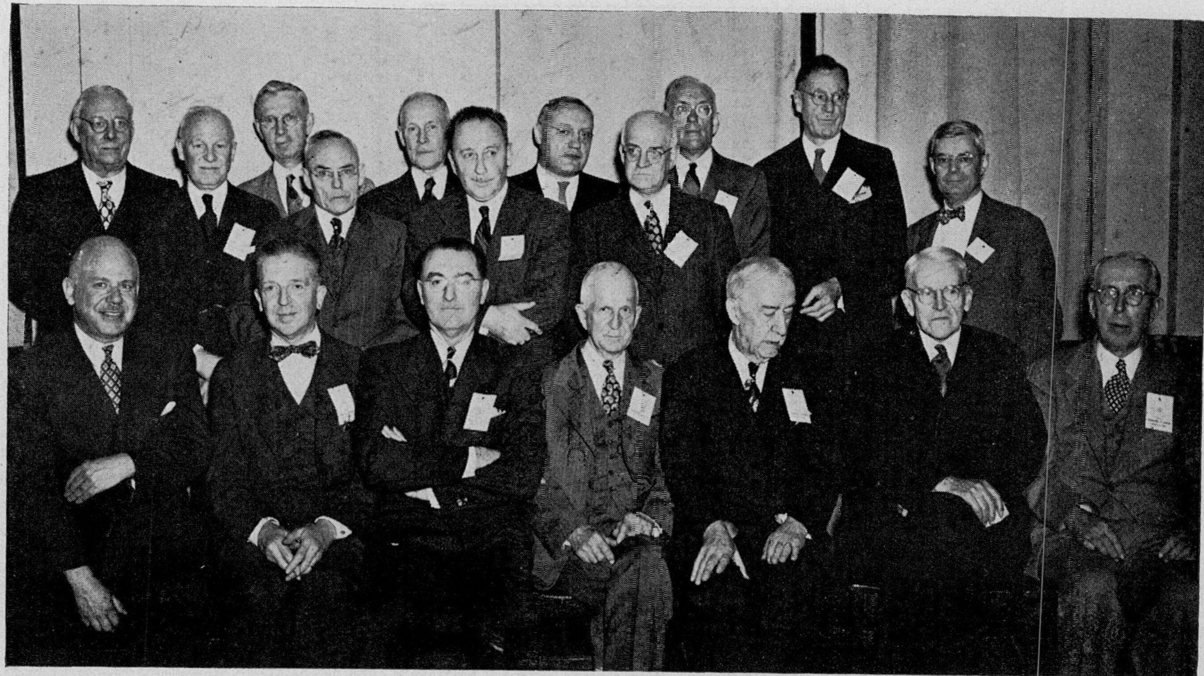

Courtesy of "New England Construction"

PAST PRESIDENTS OF THE BOSTON SOCIETY OF CIVIL ENGINEERS AT 100TH ANNIVERSARY MEETING

Seated (left to right): G. M. Fair, A. L. Shaw, H. B. Kinnison, A. T. Safford, C. M. Spofford, C. M. Allen, H. K. Barrows.

Standing: C. B. Breed, H. M. Turner, K. R. Kennison, F. N. Weaver, G. A. Sampson, J. B. Babcock, 3d, Albert Haertlein, H. P. Burden, F. A. Marston, A. D. Weston, F. M. Gunby.

Other Past Presidents at the meeting (not included in the photograph): A. B. Edwards, C. A. Farwell, R. W. Horne.

JOURNAL OF THE

BOSTON SOCIETY OF CIVIL ENGINEERS

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Centennial Address

Centennial History

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Contributions of the Members of America's Oldest Engineering Society to 100 Years of Progress in Civil Engineering

A CENTURY OF TRANSPORTATION

BY CHARLES B. BREED, PAST PRESIDENT, B.S.C.E.*

(Presented at 100th Anniversary Meeting, Boston Society of Civil Engineers, March 31, 1948.)

Probably Transportation is the oldest of the four branches of our profession which are being presented on this program. Even neolithic man had the urge to move about. In fact he had to do so for sustenance. His next urge was curiosity. He wanted to see what was beyond the hills. Then followed the urge for conquest, in order that he might thereby possess the goods of his neighbors. Water transportation was the accepted means of travel until about 4000 B.C. Then the use of the wheel was discovered and land transportation had its birth.

With the Industrial Revolution in Europe a speedier note of transportation was required, and this challenge was met about the year 1805 when McAdam and Telford showed the world how to construct paved highways.

Then in the early 1820's, only 125 years ago, Stephenson's railroad locomotive made its appearance, and with the advent of the locomotive, New England became the center of industry in the United States.

Of the 31 founder members of B.S.C.E., 28 were in railroad construction at some time during their careers. Ten devoted their

*Consulting Engineer; formerly Head of the Department of Civil and Sanitary Engineering at the Massachusetts Institute of Technology, Cambridge, Mass.

lives to it and held prominent positions in railroad engineering, operation and management. Both the first president of the B.S.C.E., *James F. Baldwin*,[1] and the first president of the A.S.C.E., *James Laurie*, were prominent in the field of railroad construction.

In 1826 within 10 miles of Boston, the first railroad in America was constructed and operated at Quincy. This was the first of the 191 different railroads that make up the present New Haven system.

The Quincy Granite Railway was built to haul the granite blocks which were used in the construction of Bunker Hill Monument. The road ran from the West Quincy quarries to the Neponset River, and its motive power consisted of horses. Soon, however, railroad motive power changed to steam, through the use of which developed the 230,000 miles of railroad in this country.

The first electrification of a steam railroad took place only a few miles from Boston, when, in 1895, it was used on the Nantasket Beach Branch of the Old Colony Railroad. Charles P. Clark, President of the New Haven Railroad, foresaw the great possibilities of electric traction as applied to steam railroads, and to him belongs the credit for electrifying this line.[2]

Of the many members of the Society who were prominent in the transportation field, the careers of the following are typical.

RAILROADS

James F. Baldwin was the son of Colonel Loammi Baldwin, who built the Middlesex Canal from Boston to Lowell. He was a younger brother of Loammi Baldwin (2nd), who has often been called the "Father of Civil Engineering in America." *James Baldwin* in 1828 made a survey for a railroad from Boston to the Hudson River under the authorization of the State Board of Internal Improvements. His survey was the basis for the location of several railroads which were subsequently built. He was chief engineer for the construction of the Boston & Lowell R.R., and later served as a commissioner for the construction of the first Boston water supply. *Baldwin* was elected President of the Society at its founding in 1848.

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[1] B.S.C.E. membership is identified by italics in text.

[2] A story is told that President Clark who was much interested in the details of the new electrification projects, wanted to know about the flow of current in a third-rail. He asked eleven engineers whether the current was concentrated on the surface of the third-rail or was distributed throughout the rail, and was reported in an interview as saying, "five said 'on the surface', and five said 'throughout' "; he was inclined to agree with the eleventh fellow who said he did not know!

Samuel Nott, at the age of 18, became a rodman on the construction of the Boston & Worcester R.R. in 1833. Later he was appointed division engineer on the construction of the Eastern R.R. and its extension the Portsmouth, Saco & Portland R.R. The Eastern R.R. first terminated in East Boston and the passengers were ferried to Boston. (Until 1910, only 38 years ago, the Pennsylvania Railroad terminated on the New Jersey shore and passengers were ferried to New York City.) *Nott* served as chief engineer on construction of the Manchester & Lawrence R.R. and of the Concord & Portsmouth R.R. Later he became superintendent of the Hartford, Providence & Fishkill R.R., holding this position for more than twenty years.

He was elected a director at the founding of the Society in 1848 and subsequently served as secretary for many years, until its reorganization in 1874.[3]

James Laurie was chief engineer of the Norwich & Worcester R.R. It is probable that this was the first railroad in the United States on which a tunnel was built. He was also connected with other New England railroad projects, including surveys and a report on the Hoosac Tunnel. Perhaps his greatest work was the design of the iron lattice bridge across the Connecticut River at Warehouse Point, for the New Haven, Hartford & Springfield R.R. of which he was chief engineer in 1862.

He was a founder member of both the B.S.C.E. and the A.S.C.E. and served as first president of the latter. He presented the first paper before each of these societies. The "James Laurie" A.S.C.E. prize was established in his honor.

Samuel M. Felton taught mathematics to the civil engineering students of Loammi Baldwin (2nd), and after Baldwin's death, he continued the work.[4] He was chief engineer for the eastern section of the Fitchburg R.R., and later was appointed its superintendent. In 1851 he became president of the Philadelphia, Wilmington & Baltimore R.R., which he developed successfully. It was he who arranged for the safety of Abraham Lincoln on his famous trip through Baltimore to take the oath of office in Washington. *Felton* served also as president of the Pennsylvania Steel Company and was a commissioner for Hoosac Tunnel. He was a director of the B.S.C.E. from 1849-51.

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[3]A photograph of Samuel Nott is shown on p. 374.

[4]See p. 363 for a discussion of the education and training of Boston's early civil engineers.

FIG. 1.—RAILROAD PASSENGER STATIONS AND PROPOSED TREMONT STREET SUBWAY, 1894.

This map was presented in the program of the 27th Annual A.S.C.E. Convention held at Hotel Pemberton (Hull) in June, 1895. It shows four separate passenger stations on Causeway St., which is incorrect. The passenger tracks of the Boston & Maine R.R. continued across Causeway St. (see Fig. 2), to a station at Haymarket Square. The first North Station was built in 1894 on Causeway St. (between Nashua and Haverhill streets); and was used by the B.&M. (including Boston & Lowell and Eastern) and by the Fitchburg (which became part of B.&M. system in 1900).

Construction of the Tremont Street Subway started March 28, 1895. The section from the Public Garden to Park St. was opened Sept. 1, 1897; it was opened to North Station Sept. 3, 1898.

Thomas Doane was trained in the offices of Loammi Baldwin (2nd) and *Samuel Felton.* He was in charge of the construction of the Vermont Central and Cheshire Railroads. In 1863 he became chief engineer of the Hoosac Tunnel and revised its alinement, *"boldly locating on a tangent throughout."* Here he was the first engineer in the United States to make use of the compressed air rock drill and to substitute the use of nitroglycerine (forerunner of dynamite) for black powder. The Hoosac Tunnel is 4½ miles long and, at the time it was built, was the longest railroad tunnel in the United States.

In 1869 he was chief engineer of the Burlington & Missouri R.R. (part of C. B. & Q. system), and consulting engineer for other western railroads. While in Nebraska he was instrumental in founding a college at Crete, which was named Doane College.

He was the first president of the Society when it was reorganized in 1874 and served for eight years.[5]

The past century has been an era of great railroad expansion.[6] Between 1835 and 1855 the railroad mileage in Massachusetts increased from 50 to 1200 miles; and in New England, from 50 to 3500 miles. Between 1870 and 1890, 18 miles of railway were constructed every day in the United States. This huge expansion was followed by the consolidation of hundreds of small railroad corporations and the building of great terminals, such as:

Pennsylvania Station, New York City,	constructed in	1910
Grand Central Terminal, " " "	" "	1912
North Station, Boston, constructed in 1894 and entirely remodelled in 1928		
South Station, Boston,	constructed in	1898
St. Louis	" "	1894

In 1890 Boston had 8 separate passenger stations; 4 on the north side of the city and 4 on the south side. The New York & New England R.R. station was located on the site of the present South Station. The Boston & Providence station was at Park Square and the Boston & Albany and Old Colony stations were on Kneeland St. The Boston & Lowell, Eastern and Fitchburg stations were on Causeway St. and the Boston & Maine at Haymarket Sq. (Fig. 1.)

The South Station was built between 1896 and 1899 and into this passenger station all the south side railroads were received. Many B.S.C.E. members were engaged in its construction, and *George B. Francis*, a past president of the Society, was perhaps the most outstanding of this group. He built the Providence Terminal of the New Haven R.R. before coming to Boston to supervise the construction of the South Station. He became one of the best known railroad engineers in the country.

The consulting engineers for the construction of the South Station were *Fayette S. Curtis, Lawson B. Bidwell,* and *Walter Shepard. Curtis* was vice president of the N. Y., N. H. & H. RR. *Bidwell,* a past president of the Society, was chief engineer of the New York & New England R.R. *Shepard* was chief engineer of the Boston & Albany R.R.

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[5]A photograph of Thomas Doane is shown on p. 379.

[6]The 100th anniversary of the Galena & Chicago Union R.R. (now part of Chicago & North Western system) is being celebrated this year. It was the first railroad to run out of Chicago to the west.

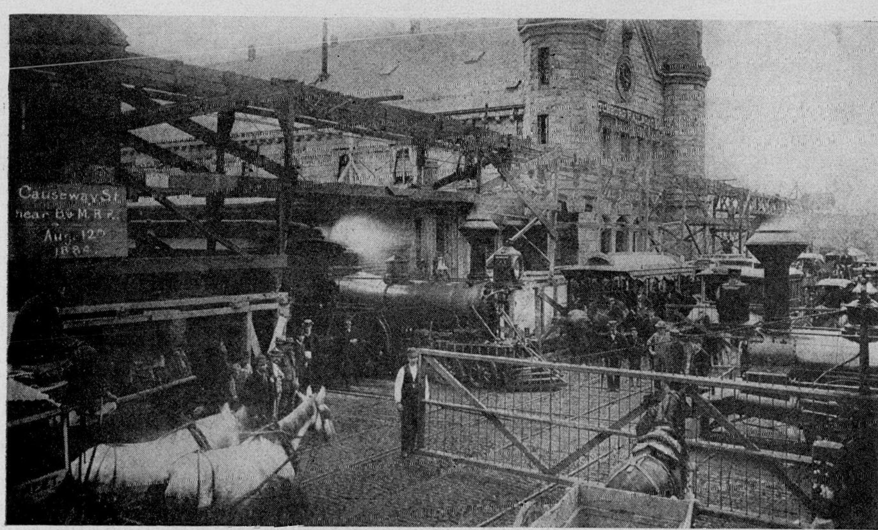


FIG. 2.—CAUSEWAY STREET IN FRONT OF RAILROAD STATIONS, 1884.

This photograph shows construction of trunk sewer in Causeway Street with railroad and street traffic maintained on the surface. The trestle-like structure is the trench excavating machine, invented by Howard A. Carson, then in charge of sewer construction for the Boston Main Drainage Works. Locomotives are those of the Boston & Maine R.R. which terminated at Haymarket Sq. (to right of picture). The stone building is the Fitchburg R.R. station. Stations of the Boston & Lowell and the Eastern railroads would be just to the left of picture.

Horse cars are shown in front of Fitchburg station. In left foreground may be seen the front of an omnibus, a few of which were still in operation at that time.

Hezekiah Bissell was engaged in the construction of the Union Pacific R.R. when its rails reached those of the Central Pacific at Promontory, Utah, in 1869. He served as chief engineer of the Eastern R.R., and when it was consolidated with the B. & M. in 1884, he became chief engineer of that railroad. By 1900 the B. & M. included the Boston & Lowell and the Fitchburg railroads (Fig. 2). In 1894 the first Union (North) Station was built on Causeway St. *Bissell* was in charge of the design and construction of this project. After his death, *J. Parker Snow,* a well known bridge engineer, served as chief engineer for two years.

Arthur B. Corthell, who had worked with *George B. Francis* at Providence and Boston, was later in responsible charge of much of the work on the Grand Central Terminal in New York. He returned to Boston in 1911 as chief engineer of the B. & M., and served until his death in 1924.

During the years 1926 to 1929, the B. & M. Boston terminal facilities, passenger and freight, were largely revamped. *William J. Backes* was chief engineer at the time the new North Station was built in 1928. *Frank C. Shepherd* served as construction engineer during the period when many of these important B. & M. changes were underway (Fig. 3.).

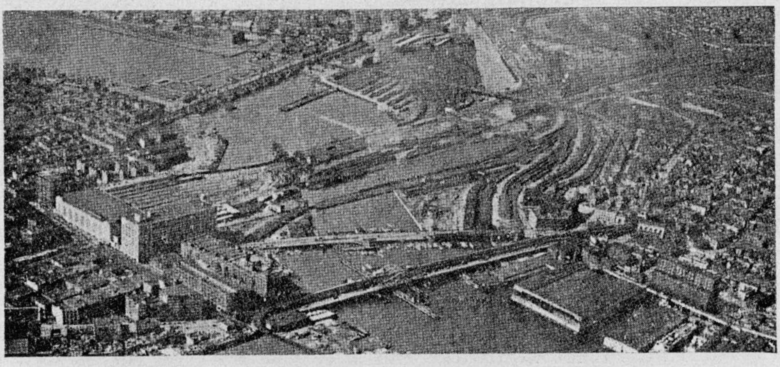


Fig. 3.—Terminal Improvements of Boston & Maine Railroad, 1930.
At the left: Manger Hotel (then under construction), new North Station with Boston Garden built above it, and B. & M. Office and Industrial Building. Across the river: New freight house facilities, engine terminal, fruit and vegetable terminal and classification yards.

Grade crossing elimination between railroads and highways was an important part of the work of the railroad engineer from 1890 to 1910. Many of our Society members were prominent in this work. Among them might be mentioned *Edmund K. Turner,* for 18 years chief engineer of the Fitchburg R.R., who became an outstanding engineer in the field of grade crossing elimination; and *James W. Rollins,*[7] a railroad engineer who later became a prominent contractor on the construction of a number of these projects.

The great strides in the development of our vast nation-wide railway system—and our 3,000,000 miles of highway—are due almost entirely to the vision and skill of this country's eminent civil engineers.

Urban and Rapid Transit

Meanwhile in Massachusetts, local transportation advanced from the omnibus to the horse car and then to the electric car. In 1897 the Tremont Street Subway was built, the first subway for electric

[7]President of the Society, 1912-13.

cars in America. Each step was part of a gradual evolution into our Metropolitan Transit Authority of today. During this time progress in transportation was advancing in all of the great cities throughout our country.

Then with the coming of the automobile, improved construction of highways was required, and bituminous macadam roads began to replace those of local materials such as gravel, sand and water-bound macadam.

The stage coach or omnibus furnished local public transportation in Boston and its environs when the Society was founded in 1848.[8] The first horse car was run on the Cambridge (Horse) Railroad between Harvard Square and Bowdoin Square on March 26, 1856. The network of horse-car lines expanded rapidly during the next 25 years. *John H. Blake,* a founder member of the Society, served as president of the Metropolitan and the Middlesex Railroad companies in the horse-car days.

By 1888 the principal street car companies were consolidated as the West End Street Railway, and the first part of the system was electrified early the next year (Fig. 4.).

The development of rapid transit in Boston stemmed from the comprehensive studies and report of the Rapid Transit Commission of 1891. In this report it was recommended that a North Union Station and a South Union Station be built and that a street car subway and elevated lines be constructed. Society members connected with the Rapid Transit Commission included *William Jackson, Frederic P. Stearns,*[9] *Alphonse Fteley* and *George S. Rice.*

In 1897 the Tremont Street Subway was opened, the first street car subway in the United States (See Fig. 1.). It was built by the Boston Transit Commission, of which *George F. Swain* was a commissioner. Professor *Swain* served throughout the entire life of the Transit Commission (1894-1918); he was chairman from 1913 to 1918.[10]

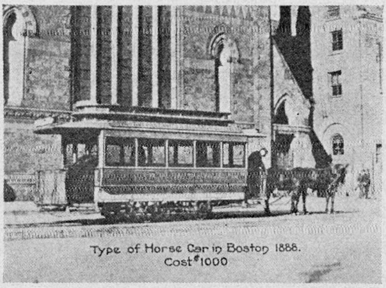
Howard A. Carson was chief engineer for the Transit Commission for 15 years.[11] *Edmund S. Davis* was his successor and served from

[8]In 1849 the Harvard Branch Railway was built from the Fitchburg R.R. at Union Square, Somerville to Harvard College, but with the advent of the horse car lines between Boston and Cambridge it was abandoned.

[9]A photograph of Frederic P. Stearns is shown on p. 330. He was president of the Society, 1891-92.

[10]A photograph of George F. Swain is shown on p. 338. He was president of the Society, 1896-97.

[11]Howard A. Carson was chief engineer of the Metropolitan Sewerage Commission at the time of his appointment. Before that he had been in charge of the construction of sewers in



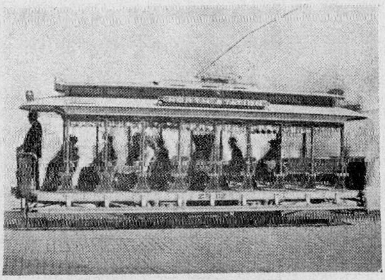


FIG. 4.—HORSE CAR AND EARLY TROLLEY CAR.

1911-18. Many other members of the Society were connected with this commission, including *Henry H. Carter* who served as consulting engineer. It was a B.S.C.E. engineered job! The estimated cost of the Tremont Street Subway (Boylston and Pleasant Streets to the North Station) was about $5,000,000; the actual cost was only $4,360,000 (Fig. 5.).

FIG. 5.—CONSTRUCTION OF TREMONT STREET SUBWAY AT PARK STREET, BOSTON.

Boston, where he had invented the trench excavating machine shown in Fig. 2. He was president of the Society, 1898-99.

The East Boston Tunnel, completed in 1904 by the Transit Commission, was the first sub-aqueous tunnel for street cars which was built entirely of concrete. Other projects completed by the Transit Commission were the Washington Street Tunnel, subway under Beacon Hill, Boylston Street Subway, and Dorchester Subway to Andrew Square.

The Boston Elevated Railway, which was incorporated in 1894 and leased the West End Street Railway at the time the Tremont Street Subway was built, was empowered to construct elevated lines (Fig. 6.). By 1901 the line from Dudley Street to Sullivan Square (via the Tremont Street Subway) was in operation. Subsequently extensions were built to Forest Hills and to Everett. The Cambridge Subway was built by the Boston Elevated Railway. *George A. Kimball*[12] was the chief engineer of elevated lines. He was in charge of design and construction until his death in 1912. Others, like *Clarence T. Fernald,* were also active on these construction projects. *Harry M. Steward* was in charge of maintenance of way for 35 years. *Eugene C. Hultman* was engineer for the West End Street Railway for many years.

Highways and Parks

William E. McClintock was often referred to as the "Father of Good Roads" in Massachusetts. In 1892 he was engineer member of a commission to investigate the improvement of highways in Massachusetts. This investigation resulted in the formation of the Massachusetts Highway Commission in 1893. *McClintock* was made a member and was chairman of that commission from 1898-1908, when he resigned to devote his services to the rehabilitation of his home city of Chelsea after its tragic fire. *McClintock* had much to do with the development of the well-known Massachusetts bituminous-macadam type of road. He was one of the organizers of the Massachusetts Highway Association and served as its first president. He was a past president and honorary member of our Society.

Harold Parker, a son of founder member *George A. Parker,* was a member of the Massachusetts Highway Commission from 1900 to 1911, and its chairman from 1908-11. *Charles Mills* was the first chief engineer of the Commission.

John R. Rablin started his career with the Metroplitan Park

[12]President of the Society, 1902-03.

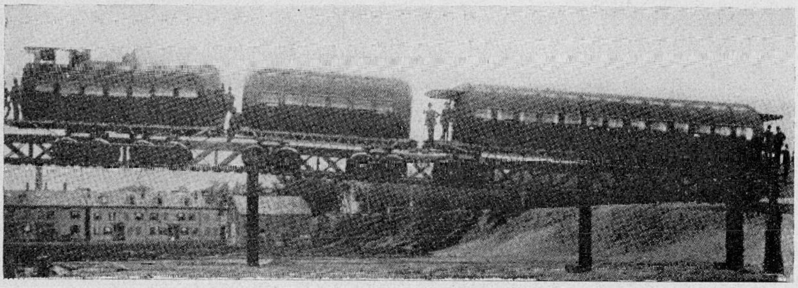


FIG. 6.—MEIGS ELEVATED RAILWAY PROPOSED FOR BOSTON.

Full-size operating model, built in East Cambridge in 1886, of Meigs Elevated Railway which had been authorized to build a line from "some point in Cambridge" to Bowdoin Square, Boston. The structure included a single longitudinal truss supported on iron columns; the train, carried centrally above the truss, was supported on large, grooved-rim wheels, with axles set at 45° to the horizontal, rolling on rails fastened to the lower chord of the truss.

Although this company did not build the proposed line, the Rapid Transit Act of 1894 authorized the newly-formed Boston Elevated Railway to construct its elevated lines according to the patents granted to Joe V. Meigs, or according to such other plans as the Board of Railroad Commissioners approved. It was finally decided that Boston's elevated lines should be built with standard type of construction and equipment.

Commission in 1899 and was its chief engineer from 1904 until his death in 1928. During this period there was a great expansion of the Metropolitan Park system; this included the construction of roads, bridges and recreational areas.

Frank O. Whitney was chief engineer of the Street Laying Out Department of the City of Boston for many years. He served as treasurer of the Society for 15 years.

The advent of automotive vehicles on the highways has resulted in revolutionary changes in highway design and construction methods. Some of these changes were taking place in the first decade of the 20th century when *McClintock* and *Parker* were members of the Massachusetts Highway Commission. But the most important highway developments are those of more recent years. Several of the present members of the Society have made outstanding contributions to highway engineering during this latter era.

Frank W. Hodgdon served the Commonwealth of Massachusetts for 47 years—with the Board of Harbor Commissioners, the Directors of the Port of Boston, and the Waterways Division, Department of Public Works. He was active in river and harbor improvement, and in the construction of Commonwealth Pier and the Dry Dock at South Boston. He represented the State in the supervision of the construction of the Cape Cod Canal by a private company. He reported on the Traffic Tunnel (vehicular) to East Boston. He also supervised the start of the airfield at East Boston. *Hodgdon* was president of the Society, 1906-07.

The layout and construction of vast airports to accommodate our rapidly growing commercial air transport has become one of our most important fields of Transportation Engineering. But this is of such recent origin that its development is in the hands of present members of our Society; it is not the province of this paper to include living members.

It is not possible in a paper of this limited scope to include the accomplishments of all the eminent transportation engineers who were members of the Boston Society of Civil Engineers. However, the careers herein sketched bear eloquent witness to the contributions to Civil Engineering which were made by these men, and others toward the development of transportation in our Commonwealth and throughout the United States.

Contributions of the Members of America's Oldest Engineering Society to 100 Years of Progress in Civil Engineering

CONTRIBUTIONS TO SANITARY ENGINEERING

BY GORDON M. FAIR, PAST PRESIDENT, B. S. C. E.*

(Presented at 100th Anniversary Meeting, Boston Society of Civil Engineers, March 31, 1948)

Sanitary Engineering is as Bostonian in its origins as are baked beans and brown bread. The evolution of sanitary thought, I grant you, is cosmopolitan and ageless, but incorporation of the principles of sanitary science into an engineering discipline in the latter half of the nineteenth century is, in my opinion, forever bound to the city of Boston and to the Commonwealth of Massachusetts, and within them, to their governments and public works; to the social conscience of their people and their departments of health; to their teachers and educational institutions; and—last but not least—to their engineers and the Boston Society of Civil Engineers.

Sanitation as a foundation stone of the public health movement is indeed one of the dynamic manifestations which, within one brief generation, did away with incarceration for debt, reformed the prisons and the penal code, improved the care of the sick, the blind, and the insane, and crusaded for the abolition of child labor and of slavery.

During the industrial revolution, first in England and later in America, society had sinned. Men, women, and children had been worked for a pittance from dawn to dark in dangerous and ill-ventilated factory buildings. Workers and their families had been herded into dismal tenements that clustered about the factories. The sanitary facilities of the mushrooming industrial towns were grossly inadequate to satisfy new and often catastrophic public health needs. By contrast, mill owners and stockholders had grown rich, and great fortunes had been laid up in New England by merchants and finan-

*Abbott and James Lawrence Professor of Engineering, Gordon McKay Professor of Sanitary Engineering, and Dean of the Faculty of Engineering, Harvard University.

ciers who had turned from foreign commerce to the exploitation of natural resources and to the creation of native industries.

In violent reaction, society eventually found itself in a mood for atonement. It was ready for pity and for penance. In particular was it ready to support organized community effort for the protection and promotion of the health of those whom it had almost destroyed. Engineers had made possible the industrial revolution. Engineers should now provide the means to wipe out the failings of that revolution. The machine should no longer enslave but make free.

Interestingly enough, the sanitary awakening of New England was contemporaneous with what has been called the flowering of the Puritan spirit: that simultaneous and unheralded appearance in Boston and its suburbs of men and women of unusual intellectual and literary capacity. This group, as a whole, was imbued with a belief in the value of the common man and in the unbounded opportunity for him to succeed in America. The West was opening up. Its challenge was without limit, its horizon without end. Small wonder that Yankee engineers should have found in sanitary science an instrument for their belief in the goodness of things. Small wonder that sanitary engineering should have flourished at the side of transcendentalism.

Need for Sanitary Engineering

It was a happy omen for the future of sanitary engineering and the Boston Society of Civil Engineers that, as the century of this Society opened, there was staged, around the Frog Pond on Boston Common, a celebration of a great engineering and civic accomplishment. (Fig. 1.) Patriotic, fraternal, and literary societies were massed about their standards on the slopes of Beacon Hill. The Ancient and Honorable Artillery Company, brave in tailcoats and busbies, rested on its arms on Beacon Street. The rostrum for dignitaries of state, town, and church was thrown, like a flying bridge, across the waistline of the pond. Bands blared patriotic tunes; there was high oratory; and a commemorative ode[1] by James Russell Lowell was sung by the school children. Then, upon a signal, a great

[1]From which the following is quoted:

"My name is Water: I have sped
Through strange, dark ways, untried before,
By pure desire of friendship led,
Cochituate's ambassador;
He sends four royal gifts by me
Long life, health, peace, and purity."

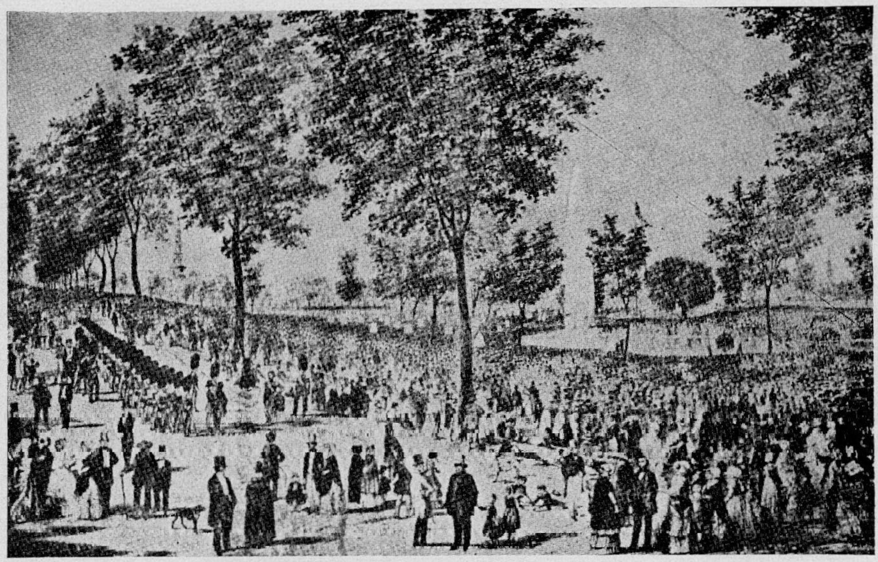


FIG. 1.—CELEBRATION AT THE FROG POND ON BOSTON COMMON ON THE INTRODUCTION OF COCHITUATE WATER, 1848

iron gate was turned, and the waters of Lake Cochituate, pouring into the distribution system, rose majestically through a fountain to heights that had the onlookers gasping with wonder and delight.[2]

The prologue to this scene had been written more than a dozen years before by Loammi Baldwin, foremost engineer of his day, when he had recommended that the city acquire Farm Pond and

[2]A charming account of these proceedings appears in N. J. Bradlee's "History of the Introduction of Pure Water into the City of Boston" from which the following extracts are quoted:

"The weather was propitious and at the break of day, a salute of one hundred guns, accompanied by the ringing of the bells, opened the ceremonies. At an early hour the streets were filled with people, attracted by the decorations, mottoes and devices, by which the principal avenues through which the procession was to pass, were embellished. These were very numerous, well arranged and in good taste, and some of them extremely beautiful."

"The SERVICES on the COMMON were brief, on account of the lateness of the hour at which the procession reached the spot; they were as follows:

FIRST, Hymn by George Russell Esq., which was sung by the Handel and Hayden Society and the audience.

SECOND, Prayer by Rev. Daniel Sharp, D.D.

THIRD, Ode by James Russell Lowell, Esq., which was sung by the School children.

FOURTH, ADDRESS by the HON. NATHAN HALE, one of the WATER COMMISSIONERS.

FIFTH, ADDRESS by the HON. JOSIAH QUINCY, JR., MAYOR OF BOSTON.

At the conclusion of the Mayor's Address, he asked the Assembly if it were their pleasure that the water should now be introduced. An immense number of voices responded, 'Aye!' Whereupon the gate was gradually opened, and the water began to rise in a strong column, six inches in diameter, increasing rapidly in height, until it reached an elevation of eighty feet.

After a moment of silence, shouts rent the air, the bells began to ring, cannon were fired, and rockets streamed across the sky. The scene was one of intense excitement, which it is impossible to describe, but which no one can forget. In the evening, there was a grand display of fireworks, and all the public buildings and many of the private houses were brilliantly illuminated."

Long Pond (later renamed Cochituate) as the source of a gravity supply for Boston (See Fig. 2). Construction, after many delays, was authorized in 1846 and *James F. Baldwin,*[3] first President of the Boston Society of Civil Engineers and brother of Loammi,[4] was made one of the Commissioners for this undertaking. *E. S. Chesbrough*[5] and *William Whitwell* were chief engineers of the western and eastern departments of the works, respectively.

Delay in construction from 1834 to 1846 had been caused by division in preference for different sources of water supply. During the period of uncertainty, a veritable barrage of pamphlets descended upon the town. Even Harvard's Professor of Obstetrics and Medical Jurisprudence, Walter Channing, who was serving as Dean of the Medical School, joined in the debate.[6]

Three times within the next hundred years new water supplies were introduced as Boston grew from a city of 128,000 souls to a metropolitan giant of nearly 2½ million inhabitants. For the development of each of these supplies, a member of the Boston Society of Civil Engineers was to become chief engineer: *Joseph P. Davis* for the Sudbury Works completed in 1878;[7] *Frederic P. Stearns* for the Wachusett Supply substantially finished in 1907; and *Frank E. Winsor* for the final westward drive to the Ware and Swift Rivers within the memory of most of us. (Fig. 2) It was characteristic of the high-minded leadership of the General Court of Massachusetts that the last two expansions were sponsored by the Commonwealth as metropolitan ventures. Control of the system of water distribution was for many years vested in *Dexter Brackett,* who eventually became the first chief engineer of the Metropolitan Water Works.

In the course of time, strangely enough, the degree of public response to engineering feats seems to have dwindled more or less in proportion to the increase in magnitude of the engineering works accomplished; the public had become dulled to the feats of the engineer.

As shown in Lowell's "Ode on the Introduction of Cochituate Water," the principle that clean water was health-giving was well

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[3]Membership in the B. S. C. E. is identified by italics in the text.

[4]Loammi Baldwin had died before the B. S. C. E. was founded.

[5]Both Chesbrough and Whitwell were members of the first Board of Directors of the Society.

[6]Channing elaborated three arguments in favor of a new source of supply, his third proposition being "That an abundant supply of pure and fresh water directly promotes health and longevity, and as surely tends to diminish or prevent pauperism." Was Channing's "Plea for Pure Water" perhaps the source of inspiration for James Russell Lowell's Ode?

[7]Alphonse Fteley, later engaged on the Croton Water Supply of New York City, was an assistant engineer on the Sudbury Works.

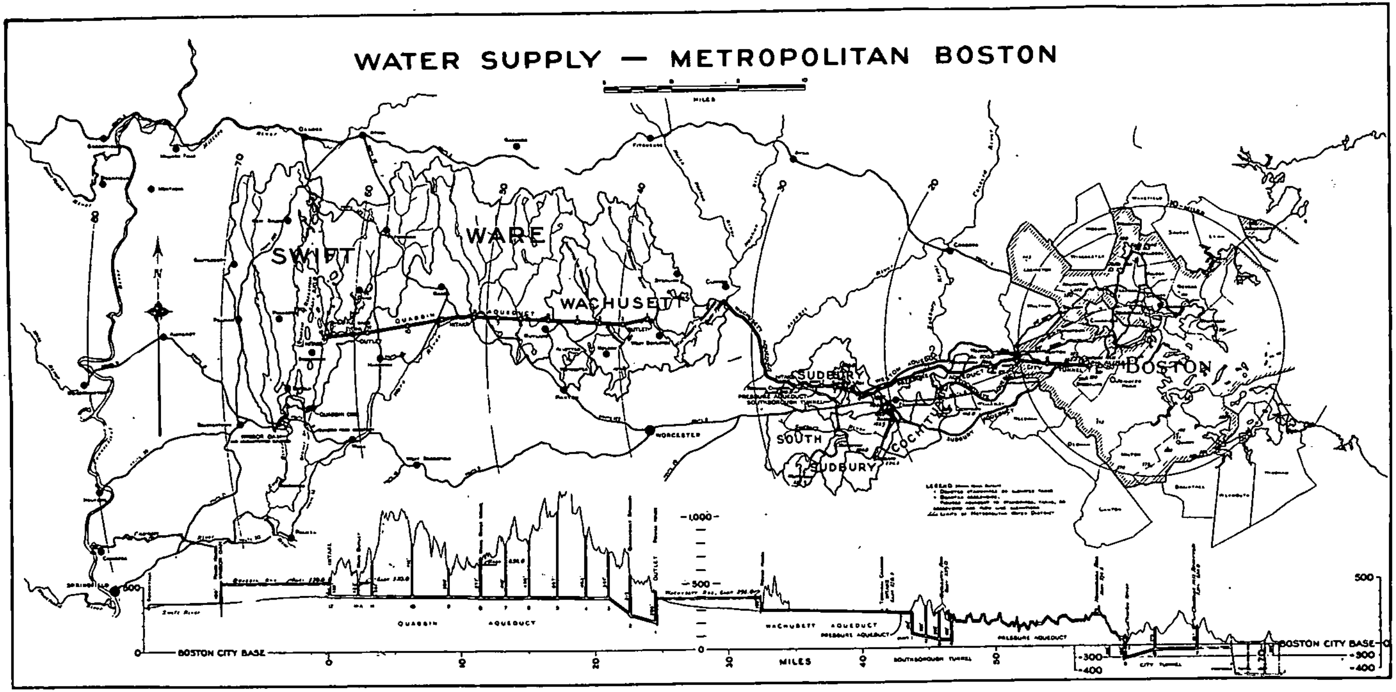

FIG. 2.—WATER SUPPLY—METROPOLITAN BOSTON

established by 1848. Many years were to elapse, however, before the causative agents of waterborne infections were to be fully identified[8] and before the art of sanitation was to give way to the science of sanitary engineering. In 1871, for example, Dr. George Derby, Secretary of the Massachusetts State Board of Health, wrote that "The single continuous thread of probability which we have been able to follow in this inquiry leads uniformly to the decomposition of organized (and chiefly vegetable) *substances* as the cause of typhoid fever as it occurs in Massachusetts." (1)[9]

In similar ignorance, as late as 1875, the commission appointed by the Mayor of Boston "to report on the present sewerage of the city . . . and to present a plan for outlets and main lines of sewers, for the future wants of the city" (2) thought that: "The point which *must* be attended to, if we would get increased comforts and luxuries in our houses, without doing so at the cost of health and life, is to get our refuse out of the way, far beyond any possibility of harm before it becomes dangerous from putrefaction." (3) Although, therefore, the members of the commission, *E. S. Chesbrough,* Moses Lane, and Dr. Charles F. Folsom, appear to have been unacquainted with the revelation in 1873 by the English physician William Budd of the nature of the relation of sewage to typhoid fever, the plan proposed by them was far-sighted and provided a sturdy framework for the ultimate sewerage of Metropolitan Boston (Fig. 3). Fecal matter, incidentally, had been rigidly excluded from Boston sewers until 1833, when the overflow of liquids from privy vaults was for the first time permitted to seep into the sewers with benefit of the municipal authorities.

The first great sewerage works to be built for Boston served the southern portion of the city. Construction was under the supervision of the city engineer *Joseph P. Davis,* who employed *Eliot C. Clarke* as his principal assistant. *Chesbrough,* the consultant on the project, was at this time city engineer of Chicago and is noted for the sewerage and water works that he constructed for that community; Lane had been associated with *Chesbrough* in Chicago and was about to become city engineer of Milwaukee.

The main drainage works of Boston were placed in service in 1884. They have continued to function, substantially unchanged,

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[8]The typhoid bacillus was not discovered by Eberth until 1880.
[9]References in parenthesis are shown at end of paper.

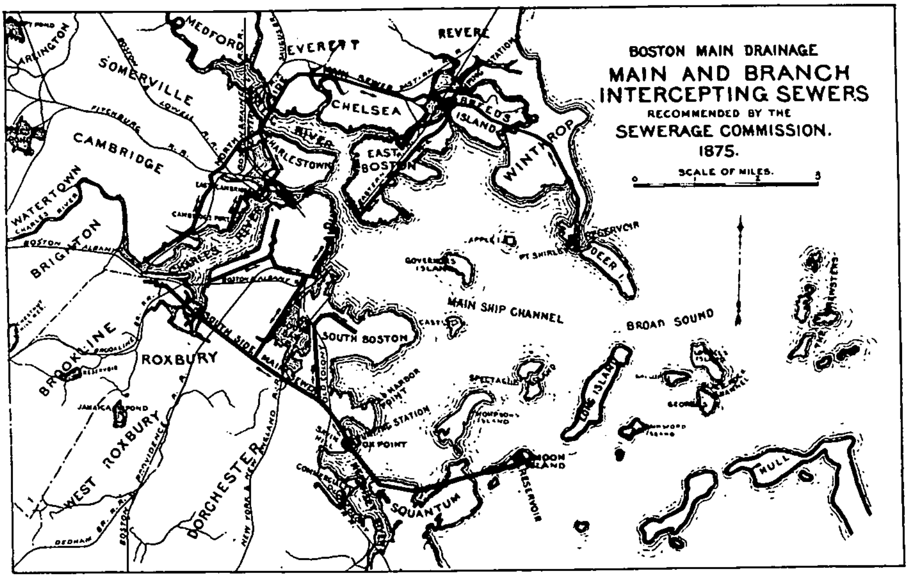

FIG. 3.—SEWERAGE SYSTEM RECOMMENDED FOR METROPOLITAN BOSTON, 1875

to this day. For a long generation *Edgar S. Dorr* was the chief sewerage engineer and gave much thought to rainfall-runoff relationships.

As Boston grew, its sewerage system, like its water system, was elaborated into a metropolitan plan. Two large-scale additions were made: the North Metropolitan System completed in 1894, and the South Metropolitan System finished in various stages between 1891 and 1909. Again members of the Boston Society of Civil Engineers were prominently connected with the development of these works under the aegis of the Metropolitan Sewerage Commission that had been appointed in 1887. *Frederic P. Stearns* was Chief Engineer, while *Howard A. Carson, Charles H. Swan,* and *Frederick Brooks* were in charge of the three main divisions of the North Metropolitan Sewerage system. *Howard A. Carson* became Chief Engineer for the initial South Metropolitan Works. He was succeeded by *William M. Brown,* who carried them to completion.

Organization for Sanitary Engineering

Although the members of this Society did thus make noteworthy contributions to civil engineering by the planning, design, construction, and operation of great and useful sanitary works, the creation of sanitary engineering as a branch of civil engineering ties back more immediately to four events that took place in the year 1886. In this memorable year, the Massachusetts State Board of Health was reorganized under the chairmanship of Dr. Henry Pickering Walcott, a physician keenly aware of the sanitary problems of public water supply and waste disposal. In the same year, furthermore, there was passed by the General Court an act of far-reaching effect. Entitled "An Act to Protect the Purity of Inland Waters," its implementation required the creation of an engineering division within the State Board of Health. *Joseph P. Davis,*[10] whose name we have already encountered in connection with the Sudbury Water Supply and with the main drainage of Boston, became the consulting engineer of this the first engineering department of an American health authority. *Frederic P. Stearns,* later to take charge of the development of the Wachusett water supply, was appointed chief engineer; and *X. Henry Goodnough* became *Stearns'* assistant and eventually succeeded him.

The origins of the Massachusetts State Board of Health trace back almost as far as the founding of the Boston Society of Civil Engineers. In 1849, by resolve of the Legislature, Lemuel Shattuck, who had been successively a schoolteacher, bookseller, and publisher, was appointed to head a commission of three "to prepare and report, to the next General Court, a plan for a Sanitary Survey of the State." (4) In a single year and almost unaided, Shattuck completed this task with the expenditure of but $500. His "Report of a General Plan for the Promotion of Public and Personal Health" was a monumental tome of more than 500 pages which outlined a system of organization for health such as is only being approached as we round out the century of its conception (Fig. 4). So advanced were the principles it advocated that they were not comprehended by contemporary men. As a result, the report was laid on the table, and most of the two thousand copies that had been ordered to be printed were consigned to the attic of the State House where they remained until they were found and put to use by Dr. Walcott.

Among the measures proposed by Shattuck was the creation of a general board of health, composed so far as practicable "of

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[10]Eventually, Davis became chief engineer of the American Bell Telephone Company and of its successor, the American Telephone and Telegraph Company.

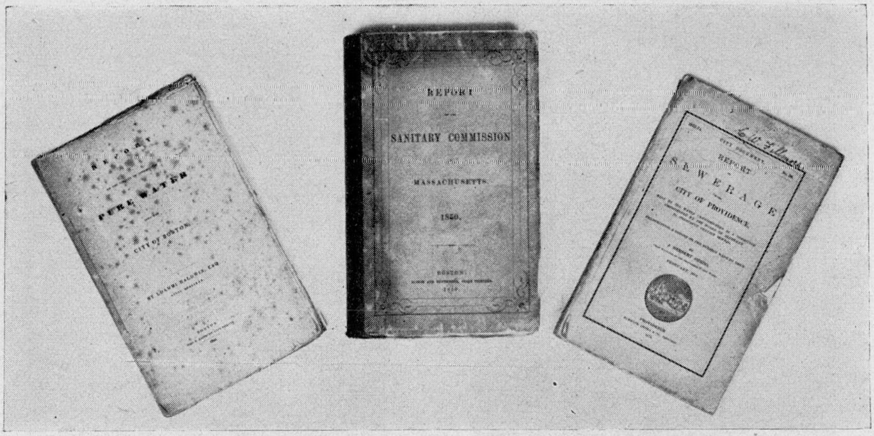

FIG. 4.—IMPORTANT SANITARY ENGINEERING REPORTS

Left: "Report on the Subject of Introducing Pure Water into the City of Boston," Loammi Baldwin, 1834; center, "Report of the Sanitary Commission of Massachusetts," 1850; right, "Report on Sewerage in the City of Providence," J. Herbert Shedd, 1874.

two physicians, one counsellor-at-law, one chemist or natural philosopher, one civil engineer, and two persons of other professions or occupations; all properly qualified for the office by their talents, their education, their experience, and their wisdom." (5) The engineer member of the proposed board was to possess "competent knowledge to determine the best methods of planning and constructing public works, and the best architectual sanitary arrangements of public buildings, workshops and private dwelling-houses." (6) Does not this recommendation contain the germ of sanitary engineering "like a grain of mustard seed which a man took and cast into his garden; and it grew and waxed into a great tree"?[11]

Almost two decades elapsed, and a great civil war was fought, before the Massachusetts State Board of Health was ultimately established. Although the board included an engineer member[12] in of note, it was not until the advent of *Hiram F. Mills* to the board due course and, upon occasion, employed engineering consultants[13] in 1886 and the creation of its engineering department that sanitary engineering as such began to emerge as the fascinating and satisfying profession that it was eventually to become.

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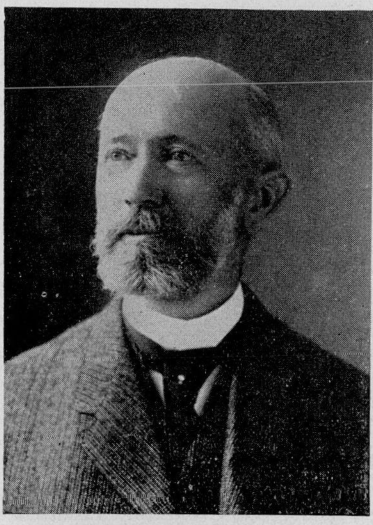
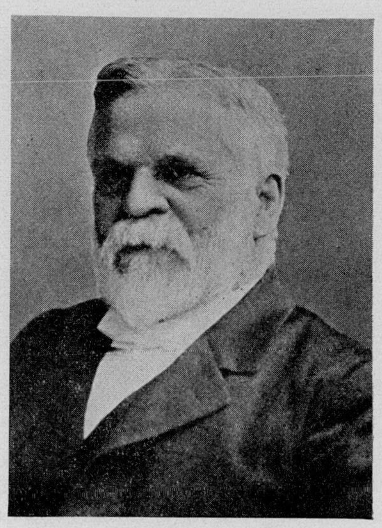
[11]Luke 13:19.

[12]John C. Hoadley of Lawrence, who served from 1874 to 1882.

[13]Among them E. S. Chesbrough and James P. Kirkwood. The latter was the first American engineer to build a municipal water filter.



Frederic P. Stearns
1851-1919



Hiram F. Mills
1836-1921

FIG. 5

Mills at the time of his appointments was chief engineer of the Essex Company which, then as today, owned the dam and canal on the Merrimack River at Lawrence and controlled the water needs of the mills. *John R. Freeman,*[14] who as *Mills'* principal assistant for many years aided him in the experiments that were conducted in the hydralic laboratory *Mills* had built at Lawrence, has the following to say about the deep, and in some ways tragic, influence of *Mills'* appointment to the State Board of Health upon his subsequent career as an hydraulic engineer(7):

> "His profound interest and zeal as an investigator were then awakened to the importance of advancing scientific knowledge in matters of purification of public water supplies and of prevention of stream pollution, and for about twenty-eight years this work of one kind and another for the Massachusetts Board of Health, for which he received no pecuniary compensation, absorbed a majority of his time, to the neglect of his earlier investigatons in hydraulic science . . ."

In 1887, *Mills* placed at the disposal of the State, for the study of water purification and waste disposal, even his hydraulic laboratory. This was an act of self-immolation for which sanitary engineers

[14]His photograph is shown on p. 388.

should be eternally grateful. The laboratory, renamed the "Lawrence Experiment Station," was the first of its kind devoted to sanitary research. Within its walls and on the land adjacent to it were to be performed experiments so fundamental and so well conceived that they continue to this day to constitute a source of reference to which sanitary engineers may turn with profit.

Education for Sanitary Engineering

In the first years of its existence, investigations of the State Board of Health that involved questions of chemistry were usually referred to Professor *William R. Nichols* of the Massachusetts Institute of Technology. *Nichols* was one of the pioneer American sanitary chemists. Another eminent chemist was *Eben N. Horsford,* trained first as a civil engineer, later becoming a pupil of the great Liebig, and Rumford Professor and Lecturer on the Application of Science to the Useful Arts in the Lawrence Scientific School of Harvard University. *Horsford's* name appears on a number of investigations of water quality and of the effect of water upon pipes.[15] It is interesting to note that in *Horsford's* day "Service Pipes for Water" was a topic of concern to so august a body as the American Academy of Arts and Sciences.

Although need for the services of "an experienced chemical philosopher" had been foretold by Lemuel Shattuck, this need did not make itself felt until the provisions of the Act to Protect the Purity of Inland Waters were put into operation in 1886. *Nichols* died in that year and was succeeded at M.I.T. by *Thomas M. Drown,* who later became president of Lehigh University. Biologists, too, among them William Thompson Sedgwick, became associated with the investigations of the engineering department. For ten years the analytical work was performed in the laboratories of the Massachusetts Institute of Technology. A happy and fruitful exchange of personnel and ideas was thereby effected. Students as well as staff became interested in the problems of sanitary engineering, and a number of young graduates of the Institute, enthusiastic for sanitary engineering through their contact, especially, with Sedgwick, were engaged by *Mills* to staff the Lawrence Experiment Station. Thus was the perpetuation of sanitary engineering assured. No

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[15]Horsford is remembered best, however, as an industrial chemist and manufacturer (after he left Harvard) of a baking powder and an acid phosphate at his Rumford Chemical Works.

longer did it depend on the fortuitous contact of civil engineers with the problems of community sanitation. Trained young men had become available and, in the spirit of the times, they were eager to follow the Emersonian injunction to hitch their wagon to a star. There ensued, in consequence, an era of sanitary investigation and progress the like of which the world has never seen again.

Hiram Mills used to say(8) that of all his discoveries his greatest was *Allen Hazen,* engineer-chemist, who had charge of the Lawrence Experiment Station during its formative years. Among the many studies completed by *Hazen* at Lawrence was his analysis of the physical properties of sands and gravels, with special reference to their use in filtration. The hydraulic principles that he enunciated in this connection were incorporated in the design, with the advice of *Hiram Mills,* of the Lawrence slow sand filters completed in 1893, and the first scientifically designed water-purification plant in America. Among the many other fundamental contributions of *Hazen* to the advancement of sanitary engineering, made after he left Lawrence to enter consulting practice, are his elucidation of the principles of sedimentation, his formulation of the flow of water in pipes, his statistical analysis of flood flows, and his generalization of storage volumes to be provided in impounding reservoirs.

Hazen was succeeded at Lawrence by *George W. Fuller,* fresh from graduate studies in Germany with Piefke[16] and other savants. In going to Europe for advanced study and observation of sanitary practice, *Fuller* continued the precedent that had been set by Boston engineers from the very inception of their concern with problems of municipal sanitation. Sanitary engineering, by this contact with developments abroad, was kept from becoming provincial in its outlook and interests. Conversely, it was not long before engineers from all parts of the world began to beat a path to the doors of sanitary engineers in Boston.

At Lawrence, *Fuller* developed means for identifying and enumerating bacteria. He became best known, however, by his investigations of water filtration at Louisville, Kentucky, and Cincinnati, Ohio. These, together with work done at Pittsburg by *Hazen,* as Consulting Engineer, and *Morris Knowles,* as Resident Engineer, as well as at New Orleans by *Robert Spurr Weston,*[17] firmly es-

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[16]Known to sanitary engineers as the author of the term "Schmutzdecke."
[17]Assistant to Fuller at Louisville.

tablished the principles of operation of rapid sand filters and the use of chemical coagulants for water treatment. The prototype for the rapid filter, it should be said, had been developed by *Edmund B. Weston,* one in a succession of extraordinarily competent city engineers of Providence, R. I.

Fuller's work in bacteriology was continued at Lawrence by *Stephen DeM. Gage,* who later transferred to the State Board of Health of Rhode Island and did notable work on the sanitary control of shellfish and of swimming pools.

Contemporary with *Hazen* and *Fuller* and of equal intellectual stature was *George C. Whipple,* like them a graduate of M.I.T. Although *Whipple* had studied civil engineering, his most effective work was done in water analysis. He concerned himself in particular with the effect of algae and related organisms upon the quality of water supplies. *Whipple* was encouraged to do so by *Desmond FitzGerald,*[18] Superintendent of the Western Division of the Boston Water Works, who gave *Whipple* his first job. Catholic in his interests, *Whipple* studied and wrote competent books on subjects as diverse as Typhoid Fever, the Microscopy of Drinking Water, the Value of Pure Water, State Sanitation, and Vital Statistics. A number of these works were completed or revised in his later years when he was professor of sanitary engineering in Harvard University. Together with William T. Sedgwick and Milton J. Rosenau, furthermore, *Whipple* organized the first school of public health in America.

With Boston blossoming into the Athens—or perhaps one would say more appropriately Rome—of sanitary engineering, a number of consulting engineers found it a congenial headquarters. Although both *Hazen* and *Fuller,* eventually, settled in New York, they, like other Massachusetts-trained men, showed their appreciation of their Massachusetts apprenticeship by maintaining, throughout their life, their affiliation with the Boston Society of Civil Engineers. *Fuller* was taken into partnership by *Rudolph Hering,* pioneer consultant in sanitary engineering, known for his connection with many early sanitary works, among them the Chicago Drainage Canal for which he proposed the long-famous dilution value of 4.0 cfs per 1000 population. Supporting evaluations of dilution requirements were made subsequently by *Stearns, Goodnough,* and *Hazen.* A partner

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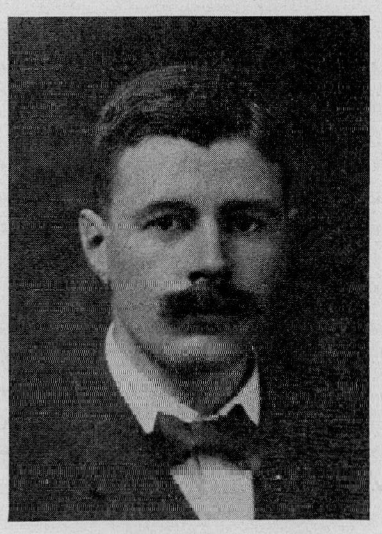
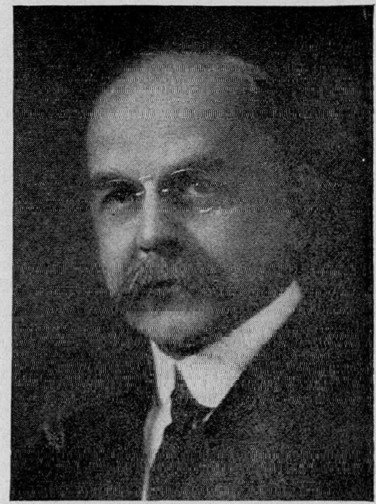
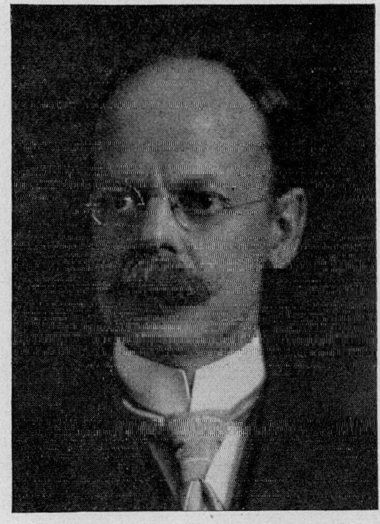
[18]Active in the reconstitution of the B. S. C. E. in 1874 after an interim of about twelve years. His photograph is shown on p. 379.



Allen Hazen
1869-1930



George C. Whipple
1866-1924



Leonard Metcalf
1870-1926

Harrison P. Eddy
1870-1937

Fig. 6

of *Rudolph Hering,* too, was *John H. Gregory,* designer of the sanitary works of Columbus, Ohio, and first professor of sanitary engineering at the Johns Hopkins University

Among early Boston consultants we must name *William Wheeler,* with whom became associated *Robert S. Weston* who, among other things, was to contribute much to the knowledge of iron removal from water. They were joined, on Beacon Hill, by *Frank A. Barbour,* who together with his partner, F. Herbert Snow, conceived the principle of sewer rentals. In the forefront for many years, however, stood *Leonard Metcalf* and *Harrison P. Eddy. Metcalf* is best known for his contributions to the knowledge of rate structures for public utilities; *Eddy* for his association with the effective adaptation of new processes of sewage treatment, including that of the activated sludge process at Milwaukee, Wis. Both men lent dignity to the profession and, by the workings of their personalities, increased the stature of the consulting engineer. *Eddy* had been a student at the Worcester Polytechnic Institute where the chemist *Leonard P. Kinnicut* was the catalyzer for sanitary engineering in much the same degree as Sedgwick was at M.I.T. Operation within the community of the first chemical precipitation plant—in its day one of the largest sewage treatment works in America—furthermore made Worcester and later, in similar fashion, Providence a center for sewage research. Sanitary interest in Worcester goes back at least to 1876 when *Phineas Ball* recommended treatment of the city's sewage by irrigation.

The sewerage of Providence is a monument to *J. Herbert Shedd* who in 1874 proposed for Providence the first comprehensive sewerage plan of an American city. *Shedd's* report stated the principles of sewerage so clearly and was so inclusive that it remained for many years a prized source book for students of sanitary engineering (see Fig. 4). *Shedd's* contributions to the development of a water supply for Providence were also very important

Most of the men whose names should find their way into this roster of sanitary engineers lived long and happy lives. There are a few, however, who were cut down all too soon. They include, in particular, *Robert W. Pratt* and *Samuel M. Ellsworth,* both men of great promise.

It has been one of the great satisfactions of my life that I entered the profession of sanitary engineering in time to know personally many of the men about whom this brief history of sanitary engineering has been written. With some of them I worked very closely: they were my teachers either in school[19] or in the office. Others I encountered in the practice of my profession. Still others I would not have had the privilege of knowing had it not been for the Boston Society of Civil Engineers which through the years has been a "Rialto" for young as well as seasoned engineers, a forum and a college for men concerned with the advancement of their profession and thereby of themselves.

As I look back, in summary, upon the first hundred years of this Society, this century of the civil engineer, these happy years of new endeavor, this golden age of sanitary engineering, I can but hold the wish that we who are assembled in commemoration of the founding of the Boston Society of Civil Engineers in the United States Hotel in the city of Boston, Massachusetts, in 1848, will be adjudged by an historian of a later day as having played our part as gallantly and well as did the men whom we have met to honor for their contributions to 100 years of progress in civil engineering.

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2. CLARK, ELIOT C., Main Drainage Works of the City of Boston, 1888, p. 22.
3. *Ibid.*, p. 23.
4. Report of the Sanitary Commission of Massachusetts, 1850, p. 3.
5. *Ibid.*, p. 112.
6. *Ibid.*, p. 113.
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For other accounts of the history of sanitary engineering in America, the reader should consult:

(a) WHIPPLE, GEORGE C., *State Sanitation*, 2 vols., 1917, Harvard University Press.

(b) EDDY, HARRISON P., GEORGE W. FULLER, SAMUEL A. GREELEY, S. H. MCCRORY, AND J. H. LE PRINCE, *Historic Review of the Development of Sanitary Engineering in the United States during the Past One Hundred and Fifty Years*, Transactions Am. Soc. Civil Engineers, 1928, p. 1207.

(c) FAIR, GORDON M., *Engineers and Engineering in the Massachusetts State Board of Health*, New England Journal of Medicine 1945, p. 443.

[19]Among them George C. Whipple and Dwight Porter, the latter for many years Professor of Sanitary Engineering at M. I. T.

Contributions of the Members of America's Oldest Engineering Society to 100 Years of Progress in Civil Engineering

100 YEARS OF STRUCTURAL ENGINEERING

By Charles M. Spofford, Past President, B. S. C. E.*

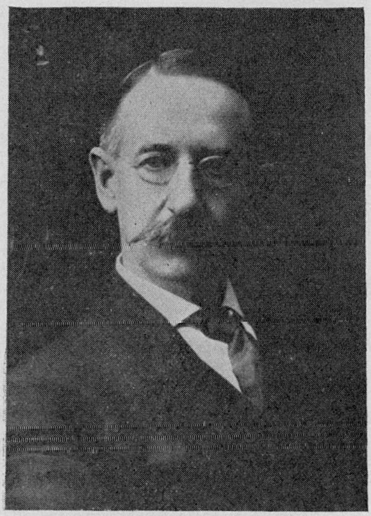
(Presented at 100th Anniversary Meeting, Boston Society of Civil Engineers, March 31, 1948)

The science of Structural Engineering has developed almost entirely during the last century and in this development members of the Boston Society of Civil Engineers have played an important part. It is true that the Romans built bridges which have in some instances resisted the ravages of time for 2000 years, but there is no evidence so far as I have been able to ascertain that the ancient Romans had any understanding of the scientific principles underlying the design of such structures. Prior to the Romans, the Sumerians built arches as early as 3500 B.C. but it is doubtful if they knew anything about the mathematical analysis of such structures. Neither the Egyptians nor the Greeks used arches and probably had no knowledge of the scientific principles underlying their design or that of other structures. As usual the art of construction preceded the theory and it was not until the beginning of the present century that the mathematical theory of structural design developed, and in this development members of our Society have taken a prominent part. Whatever progress has been made in this field by our members has been due to individual engineers of whom the following deserve special mention:

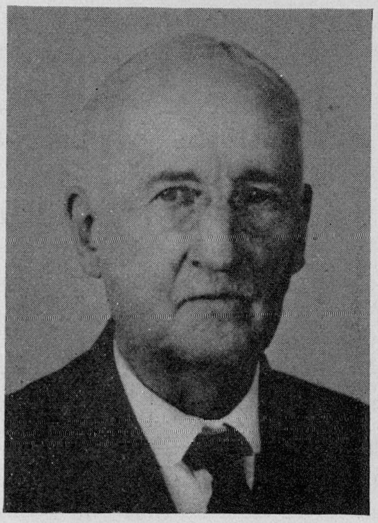
George F. Swain	1857-1931
Joseph R. Worcester	1860-1943
Frederic H. Fay	1872-1944

All of these were distinguished both in local and in national engineering circles.

*Partner in Fay, Spofford & Thorndike, Consulting Engineers, Boston, Mass.; formerly Head of the Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology.



George F. Swain
1857-1931



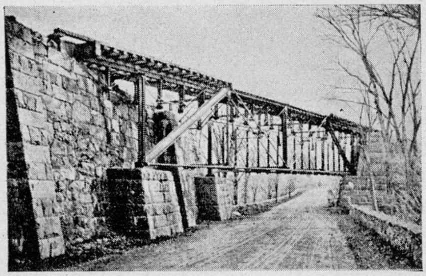
Joseph R. Worcester
1860-1943

Frederic H. Fay
1872-1944

FIG. 1

Swain[1] had perhaps more influence during his lifetime in transforming the art of structural engineering in the United States into a science than any other person during that period.

Swain, a native of California, was of Cape Cod ancestry, but instead of following the advice of Horace Greeley, "Go West Young Man," he came East to study civil engineering at M.I.T. After graduating, he spent three years of study at the Royal Polytechnicum in Berlin, specializing in structures, railroads and hydraulics, and becoming proficient in the German language. In 1881, he began his career in teaching as Instructor in Civil Engineering at M.I.T. Later, at the age of 30, he became head of its Civil Engineering Department. It was in 1887 that *Swain* first distinguished himself in the practical engineering field. In March of that year, the Bussey Bridge in Roslindale, on the Boston & Providence Railroad, failed and many passengers lost their lives. (Fig. 2.) *Swain's*



Before

After

FIG. 2.—BUSSEY BRIDGE DISASTER

analysis of the cause of the failure was so clear cut and authoritative, as compared with that of other engineers who testified at the hearing held by the Massachusetts Railroad Commission, that he was soon appointed as the first expert engineer of that Commission. In this capacity he became responsible for the safety of more than 2,000 steam and electric railroad bridges in Massachusetts, none of which failed.

Among his other engineering accomplishments should be emphasized his services with the Boston Transit Commission, to which he was one of the first to be appointed and of which he later became chairman. He also served in many grade crossing and railroad valuation cases.

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[1]Membership in the B. S. C. E. is identified by italics.

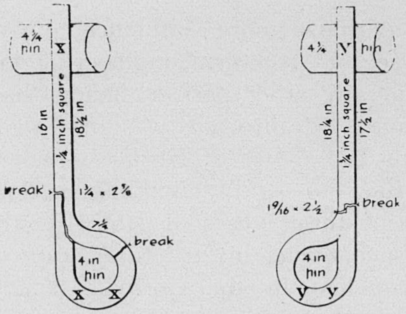


FIG. 3.—BREAKS IN BUSSEY BRIDGE HANGERS

In 1918, he was one of the representatives of the American Society of Civil Engineers appointed by the four Founder Engineering Societies of the United States to confer with French Engineers regarding the adoption of a program for the rehabilitation of France. He was also a member of the Franco-American Engineering Commission organized in 1919. For a number of years he was a member of the Board of Judges to select names for the Hall of Fame at New York University, and this University, in 1906, conferred upon him the honorary degree of Doctor of Laws.

He was a member of many scientific and educational organizations, and served as President not only of the Boston Society of Civil Engineers but also of the American Society of Civil Engineers. He was made an Honorary Member of both of these engineering societies, and served a term as President of the Society for the Promotion of Engineering Education. As an author, he presented many important papers to professional societies, and these papers materially influenced structural practices in the United States. In later years he published a three-volume treatise on materials and stresses.

The following extract from the words of Hardy Cross, when he presented *Swain* for Honorary Membership in the American Society of Civil Engineers in January 1930, is an excellent description of this noted engineer:

> "This man, this teacher, is no mere academic pedagogue. He was a man who never permitted mazes of mathematics and mazes of statistics to befog the vision of the men who studied under him. He was a prophet, a priest of clear individual thought and aggressive individual judgment."

Worcester's most important contributions to the advancement of structural engineering were his investigations and report on foundation conditions in Boston and his leadership as Chairman of the Joint Committee[2] of six organizations on Standard Specifications for Concrete and Reinforced Concrete. This Committee played a fundamental part in the development of reinforced concrete as an engineering material; and to *Worcester,* its Chairman, should go great credit for his services in this field.

Worcester, a Harvard graduate, also served as a consultant on the design of the Harvard Stadium, one of the earliest important reinforced concrete structures built in the United States, and was responsible for the design of the Cambridge Viaduct and many other structures including the beautiful arch bridge at Bellows Falls across the Connecticut River. (Fig. 4.)

Fred Fay was one of *Swain's* pupils. In fact, he was the first graduate of M.I.T. to obtain a Master's Degree in Civil Engineering. *Fay's* contributions had to do both with port development, and with the design of important bridges and air fields; also grade crossing eliminations. The Boston Army Supply Base, the Hampden County Memorial Bridge, and the bridges across Lake Champlain (Fig. 5) and across the Cape Cod Canal are outstanding contributions to structural engineering of this former President of the Boston Society of Civil Engineers.

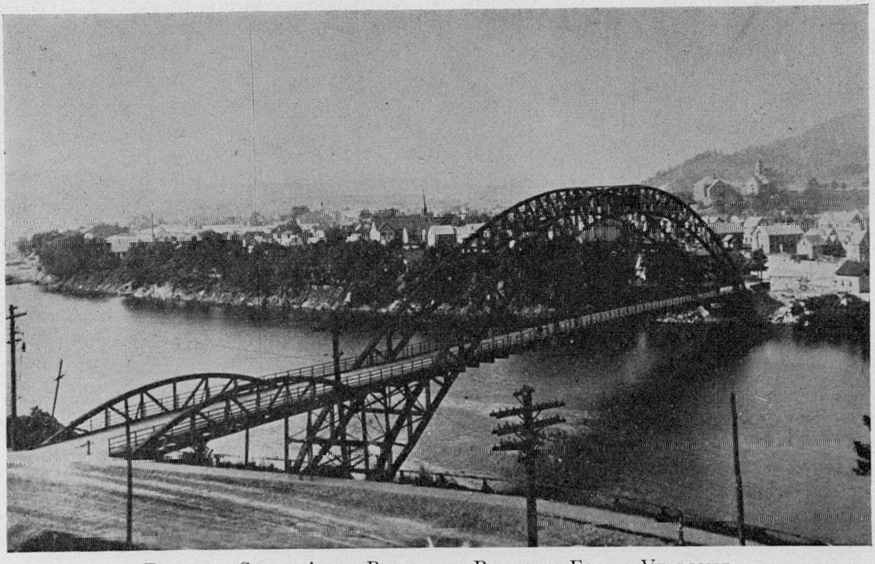


Fig. 4.—Steel Arch Bridge at Bellows Falls, Vermont

[2]American Concrete Institute; American Institute of Architects; American Railway Engineering Association; American Society of Civil Engineers; American Society for Testing Materials; Portland Cement Association.

Among his investigations and important reports was one consisting of two volumes on the Great Lakes Commerce and the Port of Oswego, New York, illustrated by many maps, tables and diagrams. This was undoubtedly the most complete report on commerce in the Great Lakes that had ever been published. Another report of 173 pages with 31 plans and diagrams was upon the elimination of grade crossings at Syracuse, New York. This report was adopted by the Syracuse Grade Crossing Commission and its recommendations have been carried out in large measure by the New York Central Railroad.

He was intimately connected with the design of the Longfellow Bridge of which *William Jackson,* City Engineer of Boston, was Chief Engineer and *John E. Cheney,* Assistant City Engineer of Boston, was Designing Engineer. *Cheney* also developed the rolling-lift type of movable bridge used with much success in Boston.

Although this paper is, by instruction of the committee in charge, confined to former members of the Society, it would seem desirable to call attention to the fact that one member of the Society still living may be considered the father of the science of soil mechanics and another member has been foremost in the application of scientific principles to the design of reinforced concrete and to cost accounting.

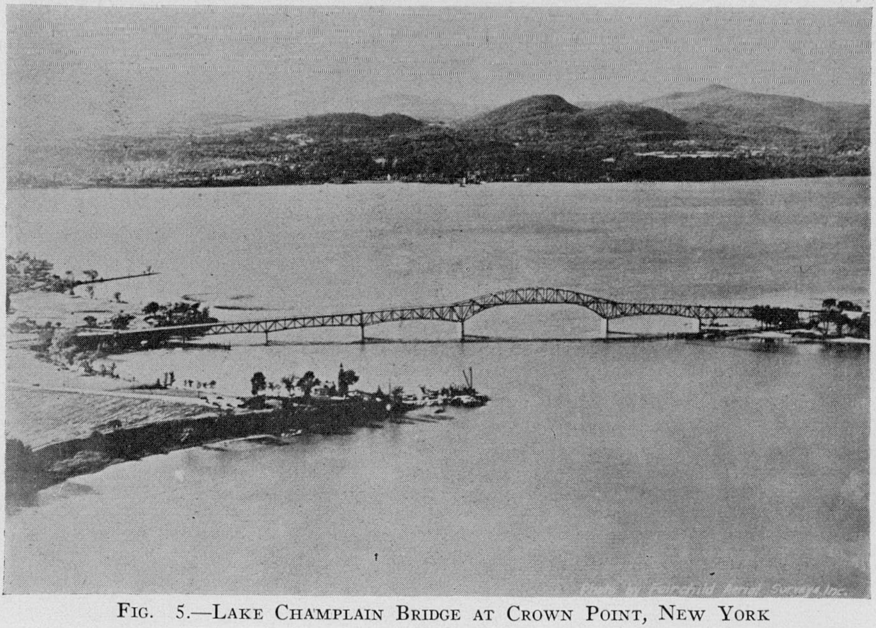


FIG. 5.—LAKE CHAMPLAIN BRIDGE AT CROWN POINT, NEW YORK

Contributions of the Members of America's Oldest Engineering Society to 100 Years of Progress in Civil Engineering

100 YEARS OF HYDRAULICS

By Howard M. Turner, Past President, B. S. C. E.*

(Presented at 100th Anniversary Meeting, Boston Society of Civil Engineers, March 31, 1948)

"The Flowering of New England" is the name of the book by Van Wycke Brooks, the eminent critic, describing the lives of the great men of letters of the last half of the 19th century. We start our history of the achievements of the members of the Boston Society of Civil Engineers at about the same time and it is also a "flowering" of great talent. It was particularly marked in the department of hydraulics which it is my part to describe.

The year 1848 was itself a notable year in this engineering field. At the great water powers at Lawrence and Lowell which had been built some years, the older forms of water wheels were being replaced with the new turbines. The latter power was also being greatly enlarged. The large dam across the Connecticut River was being rebuilt after its first failure. Water was first brought to Boston from the Cochituate supply in that year.[1] Scientific education was beginning with the Lawrence Scientific School at Harvard, just founded, and the Sheffield School at Yale starting that year.

The science of hydraulics as we know it, however, was still in its infancy. The first book in English on the subject, Storrow's "Treatise," had only been published thirteen years before. A great many of the common methods and tools of hydraulic engineering which we now have were crude or even entirely undeveloped. The engineer had to derive his own solutions of many of his problems. Some of the great achievements of these early members of the Society were their carefully conducted experiments many of which have

*Consulting Engineer, Boston, Mass.; and Professor of the Practice of Civil Engineering, Harvard University.

[1]See page 323.

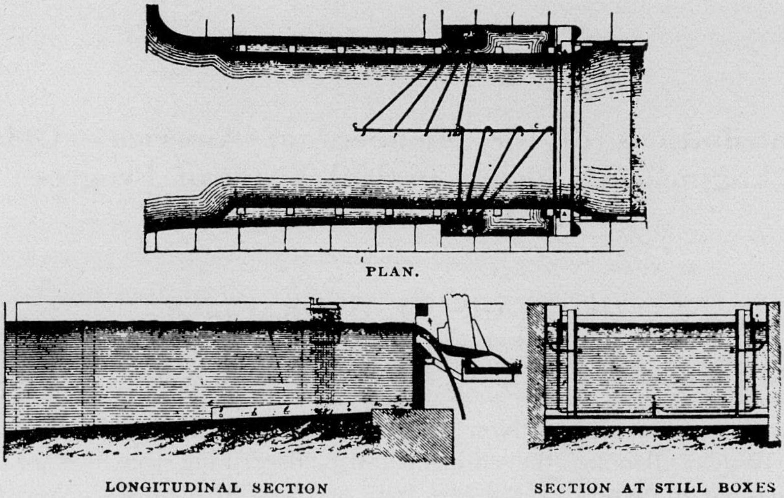


FIG. 1.—WEIR EXPERIMENT—FRANCIS' "LOWELL HYDRAULIC EXPERIMENTS"

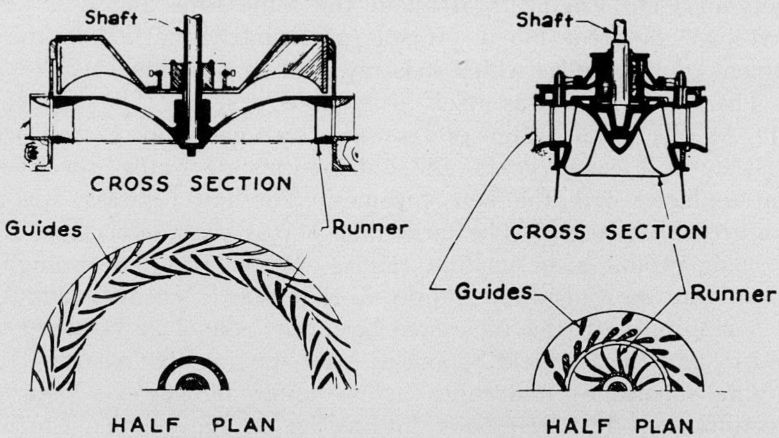


FIG. 2.—DEVELOPMENT OF FRANCIS' TURBINE
Left: Original type Right: Modern type

not needed to be repeated. They were most of them research scientists as well as practical engineers. They had to be!

I have selected from the Society's history certain men whose lives and achievements show the work that has been done by the members of the Society in this 100 years in advancing hydraulic engineering. Many others who have contributed have had to be omitted.

The name of *James B. Francis*[2] is one of the great names in hydraulic history. In 1837 at the age of 22, he became chief engineer of the Proprietors of Locks and Canals, the owners of the water power in Lowell, which position he held for 48 years. A great investigator and experimenter, he advanced the science of hydraulics in many ways. A great engineer, he enlarged and improved the water power at Lowell and was consulted in many important projects all over the country.

In his research at Lowell he developed the Francis weir formula, the first in which coefficients were used directly making the weir a practical and accurate meter for the flow of water. It is still the most universal and useful formula we have. The layout for his weir experiments is shown in Figure 1, which is taken from one of the beautiful copper plate engravings in his famous "Lowell Hydraulic Experiments" published in 1855.

He developed the inward flow turbine from the original patents of Howd. This led to the present American Mixed Flow Turbine, the standard type of reaction turbine which still bears his name. His original wheel and also a modern type of about the same capacity are shown in Figure 2.

Wherever one turns there are hydraulic fields that *Francis* explored. He early pointed out the possibility of upward pressure under dams and the advisability of draining the base of a dam to reduce it. He also discussed pore pressure in concrete mortar. His study of the expanding tube led the way to the use of that principle in any important applications.

As an engineer one of his great works was the construction of the Northern Canal at Lowell. (Fig. 3). It is interesting to note that except for the replacement of a few of the bronze screw gate-stems which have worn out and have been replaced, the canal and its headgates including all the structures, gates, and machinery are still in use today after 100 years. Even the original Francis turbine which provided power to lift the gates is still used.

Many of you are familiar with the story of the great gate which he built in 1848 at the entrance to the Pawtucket canal. His studies of the previous floods in the Merrimack River led him to believe that sometime a flood would come when it would be required. It was called "Francis' Folly" until it saved the city in the great flood of 1852. It was again used in 1936.

[2]Membership in the B. S. C. E. is identified by italics.

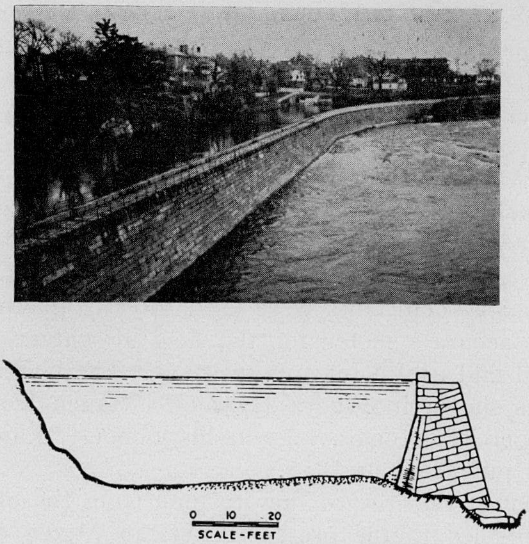


FIG. 3.—NORTHERN CANAL, LOWELL, MASS. 1848

James B. Francis was one of the founders, president, and an honorary member of the Society.

Uriah Boyden was another founder member of the Society. He was *Francis'* assistant at Lowell. His name is chiefly associated with the outward flow turbine which bore his name. Many New England mills installed Boyden wheels which were in use in some cases for more than 60 years. While his turbine was not new, his diffuser, (Fig. 4) which applied the principle of the expanding tube to slow down the velocity of the water discharging from the turbine and thus increase the power produced, was a great development. It was the forerunner of the modern draft tube now an essential part of all reaction turbines.

Clemens Herschel,[3] educated here and then in Germany, first practiced in Boston doing mostly structural work. His hydraulic career started when he was appointed engineer of the Holyoke Water Power Company in 1879. The necessity of measuring the water used by the mill water wheels led to his taking over and rebuilding in 1887 the famous Holyoke Testing Flume which was one of the first permanent hydraulic laboratories in the country. It was widely used for testing water wheels from all over the country.

[3]His photograph is shown on p. 388.

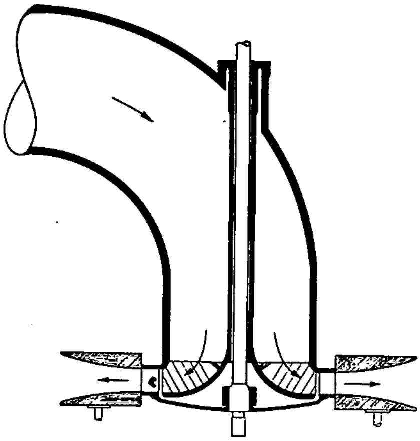


FIG. 4.—BOYDEN WHEEL AND DIFFUSER

The development of the modern turbine was largely experimental and this flume played a great part in that development providing as it did an accurate and standard test.

Figure 5 shows a longitudinal section through the flume and a chart of the increase in efficiency of the best wheels tested ranging from 81% in 1887 to 94.5% in 1931. The flume was in active use for 50 years until 1936 when, with the advent of model testing, the manufacturers built their own flumes and it was given up.

Just before *Herschel* left Holyoke, the necessity for measuring the industrial process water used by the mills there led to his most famous achievement, the invention of the Venturi meter which he named for the scientist who first introduced the principle involved 100 years before. It is still of wide application and led to the development of many forms of orifice meters using the same principle for all fluids and for many purposes. (Figs. 6 and 7). Leaving Holyoke in 1899 he later became a consulting engineer and was widely consulted on some of the most important hydraulic works in the country.

Clemens Herschel was treasurer, president, and an honorary member of the Society. He was donor of one of the prizes for meritorious papers presented before the Society. Until a few years ago this prize consisted of a copy of his translation from the Latin, "Frontinus and the Water Supply of the City of Rome".

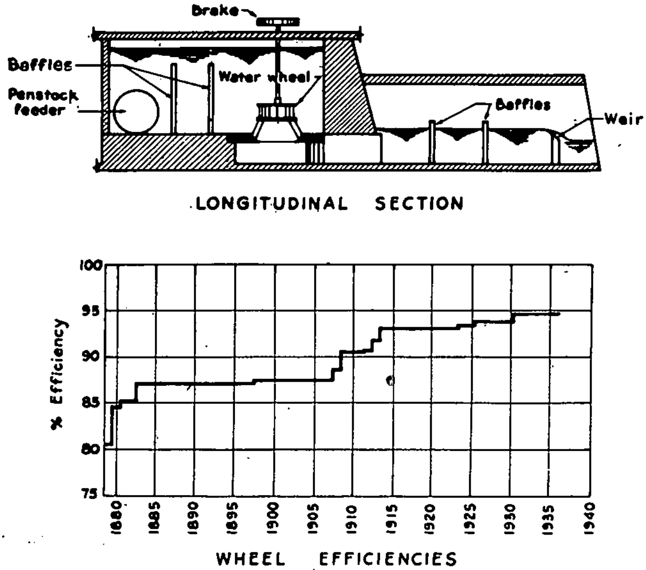
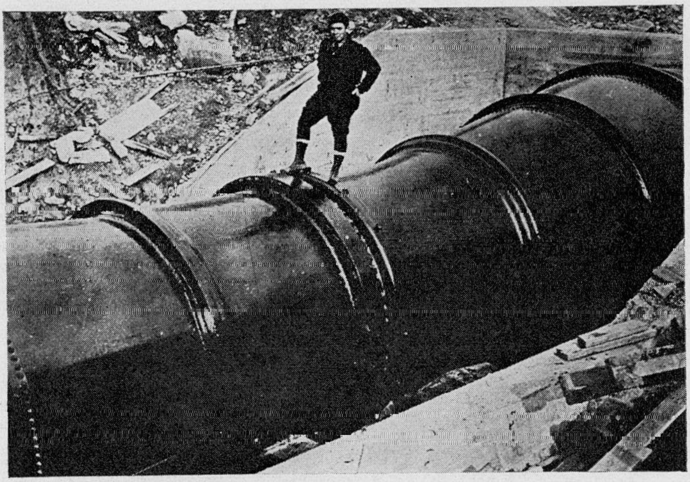


FIG. 5.—HOLYOKE TESTING FLUME

Hiram F. Mills[4] was another one of the hydraulic engineers on the Merrimack River. He became chief engineer of the water power company at Lawrence in 1869 and a few years later of the company at Lowell also. Though he is chiefly remembered, as Professor *Fair* has described, for his work for the State Board of Health, his name must be included in this hydraulic section.

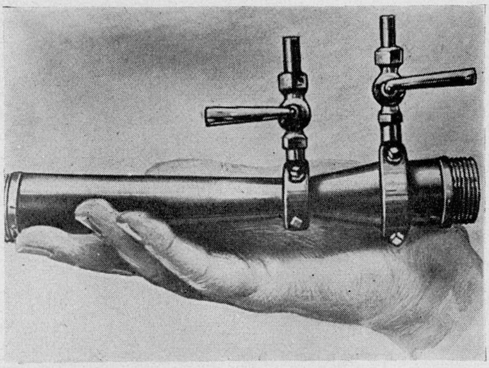
Mills was an engineer of great resource and ability. He made a great many important hydraulic experiments chiefly of the flow of water in open channels and on piezometer gages and did a great work in increasing the capacities of canals in Lowell by means of improving their hydraulics. His resource in engineering is shown in his design of retaining walls on the Pawtucket canal in Lowell which has always interested me. (Fig. 8.) As described by his successor, *Arthur T. Safford,* it consisted of "wrapping masonry around the resultant." These walls are still in service after 60 years under the extreme conditions of the varying water levels in the canal which is emptied nearly every week-end in the summer. *Mills* was for years a member of the corporation of the Massachusetts Institute of Technology.

[4]His photograph is shown on p. 330.



Courtesy of Builders-Providence, Providence, R. I.

FIG. 6.—LARGE VENTURI METER



Courtesy of Builders-Providence, Providence, R. I.

FIG. 7.—SMALL VENTURI METER

Frederic P. Stearns[5] was a self-educated engineer who rose to the very top of his profession here in Boston. He was engineer of the State Board of Health and then of the Metropolitan District Commission. His name is chiefly connected with the construction of the Wachusett Dam in Clinton, Mass. in 1900. This dam was the first dam in which upward pressure was allowed for in the design

[5]His photograph is shown on p. 330.

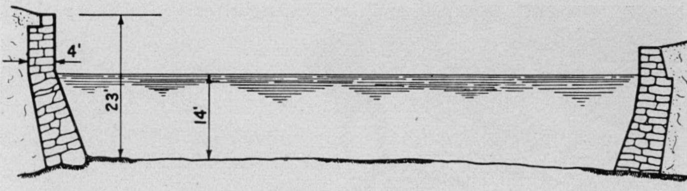


FIG. 8.—PAWTUCKET CANAL RETAINING WALLS, LOWELL, MASS.

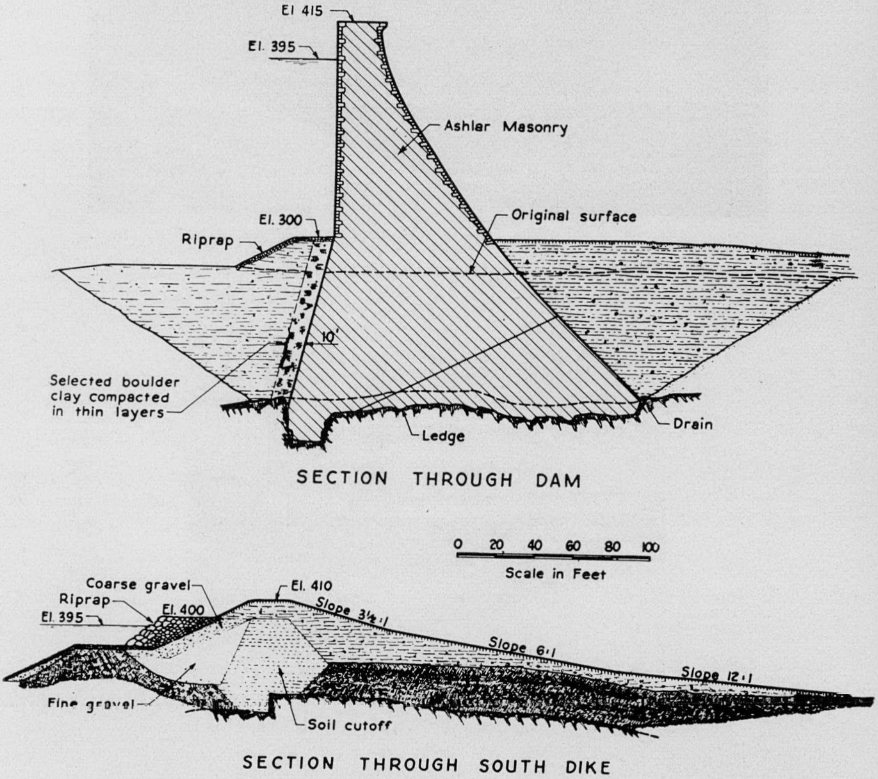


FIG. 9.—WACHUSETT DAM AND DIKE CROSS-SECTIONS, 1900

of the section by the method which is now standard, though there had been a few dams built in Europe where some allowance had been made. A cross section of the dam and one of the embankments is shown in Figure 9. The grading of the stone paving on the latter is particularly noteworthy.

Stearns contributed in many ways to the science of hydraulics. He assisted *Alphonse Fteley,* another one of the Society's prominent hydraulic engineers in the development of the Fteley-Stearns Weir Formula which is still in use. With *Fteley* he also developed a current meter. He was interested in seepage and investigated the use of a filter of graded materials for water flowing out from soil. He was widely consulted on much important engineering work including the Panama Canal.

John R. Freeman[6] was another of our great hydraulic engineers, identified now particularly with his work on fire protection for the Associated Factory Mutual Insurance Companies with which he was connected, first as engineer and later as president, for the whole period of his career. He made extensive studies of the hydraulics of fire streams and nozzles which were published in 1899 and are still the standard after 50 years. The apparatus used for these experiments is shown in Figure 10. The list of work on which he was

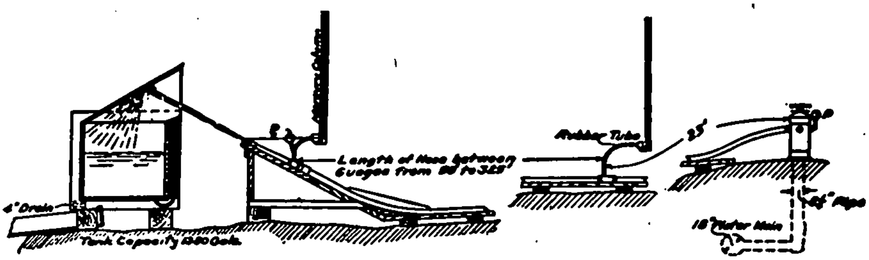


FIG. 10.—LAYOUT OF APPARATUS—FREEMAN'S NOZZLE EXPERIMENTS

consulted covered all of this country, Canada, Panama and China. His great interest in hydraulic laboratories led to an extensive study of these, most of which were then in Europe. In 1929 he published his book "Hydraulic Laboratory Practice". His work in this field gave a great impetus to the development of hydraulic laboratories in this country.

He left generous funds to three engineering societies, among them the Boston Society, the income from which has been used largely to provide scholarships, generally traveling scholarships, for young engineers in whom he always took a great interest. He was president and an honorary member of the Society and a member of the corporation of the Massachusetts Institute of Technology.

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[6]His photograph is shown on p. 388.

Allen Hazen,[7] although located in New York during the height of his career, was a member of this Society and certainly belongs with its eminent hydraulic engineers. The list of his achievements both in practice and research is a long one. He was engineer for the water supply of the city of Springfield, including the Cobble Mountain Dam on the Westfield Little River; at the time it was built in 1930 the highest earth dam in the world. It is an interesting development combining a large power plant with the water supply. Of his contributions to the science of hydraulics, I think the two most important are the pipe friction formula which he developed with Gardner S. Williams (the Hazen-Williams value of C has become a standard measurement of pipe roughness) and his work on statistical analysis in the hydrological field. His probability paper has been a valuable tool in such computations.

Frank E. Winsor made great engineering contributions, chiefly among which are construction of the Pawtuxet water supply for the city of Providence in 1921 and the extension of the Boston Metropolitan water supply to the Ware and Swift Rivers including the great dam across the Swift River completed in 1939 which bears his name. A cross section of this great construction is shown in Figure 11.

There are many others who were responsible for important work. Among them, *A. A. Conger* and *Arthur C. Eaton,* who were hydraulic engineers with the New England Power Company system, in the development of the water powers on the Connecticut and Deerfield rivers.

The last name on my list is *S. Stanley Kent.* At the time of his death in 1943 he was Engineer of the Locks and Canals at Lowell and Vice-President of the Society. As a member of the Society's Flood Committee which made its report in 1930, he was chairman of the sub-committee on Flood Formulae for New England. The concept was brought out that the time period or length of the base of flood hydrographs for all floods at a given point caused by rainfalls of comparable length is substantially the same regardless of the size of the flood. This is shown by the upper diagram on Figure 12 which shows the hydrographs of some floods of the Merrimack River at Lowell. It has been defined as "one of the fundamentals underlying some of the most valuable recent contributions to the science of hydrology". The lower diagram on Figure 12 shows characteristic

[7]His photograph is shown on p. 334.

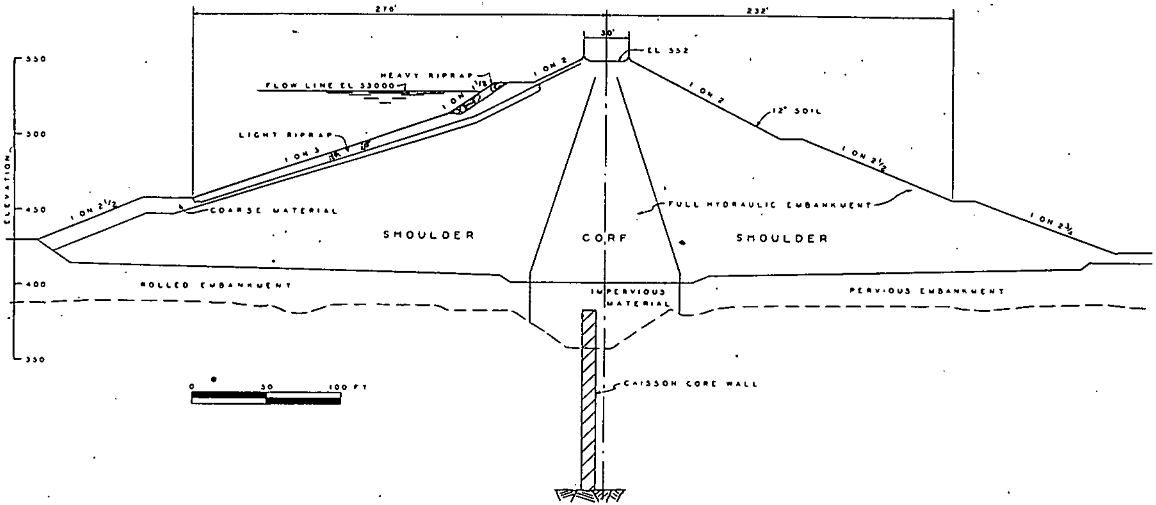
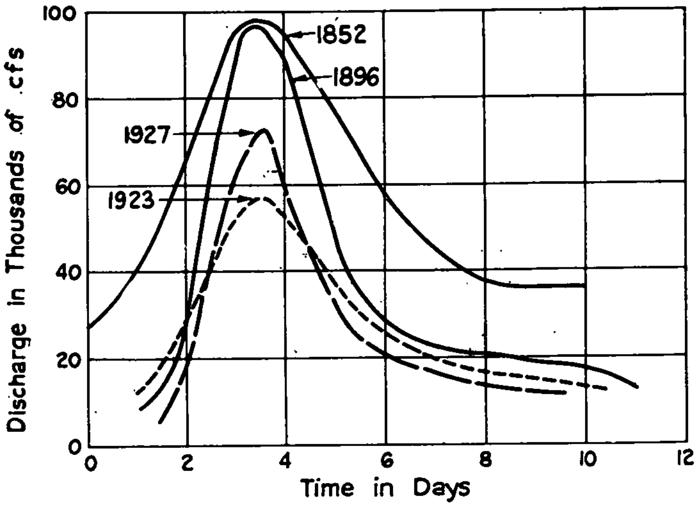
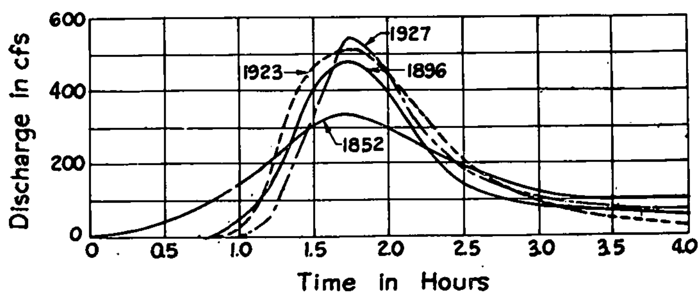


FIG. 11.—CROSS-SECTION OF WINSOR DAM, QUABBIN RESERVOIR, METROPOLITAN BOSTON WATER SUPPLY



ACTUAL FLOOD HYDROGRAPHS



CHARACTERISTIC FLOOD CURVES

FIG. 12

curves made up on a unit basis, showing the similarity of different floods at the same point. This was also a great contribution. Practically the entire credit for this work is *Stanley Kent's*.

There are many other members who in the last 100 years have made great contributions in the office, laboratory and field. The specifications for this history have required the omission of our present living members who have given and are now giving much to the science and practice of hydraulic engineering. They with others to come will continue in the next 100 years the great tradition of the first century of the Boston Society of Civil Engineers.

Centennial Address — April 21, 1948

LOOKING AHEAD

BY CARL S. ELL, MEMBER, B. S. C. E.*

Looking to the future is perhaps a habit with most of us in America. We breathe free air, we face the future without fear, we look at this great land—broad acres from the Atlantic to the Pacific; great cities with their beautiful churches, colleges, hospitals, and schools; vast transportation systems of railroads, highways, steamship and air lines spanning the continent; endless communication networks of telegraph and telephone lines and radio stations covering the nation; and we immediately feel the throb of a growing, thriving prosperous country.

Yet when this Society of Civil Engineers was organized in Boston one hundred years ago, there were only thirty stars in the American flag, the city of Boston had a population of some 127,000, the going rate for that thing called skilled labor was $1.25 a day instead of $20, Captain Robert E. Lee and Lieutenant Ulysses S. Grant were serving on the same side in the war with Mexico. America was a land of contrasts—Negroes were bought and sold in slavery while individual freedom was staunchly supported as a democratic ideal; gold had been discovered in California but poverty was widespread; there was a growing demand for scientific information to increase production and a great need for engineers of all kinds, but there was only one college of engineering over a year old in the United States.

However, we are interested in the past tonight only to the extent that it will help clarify the "Look Ahead" and point the way for the future. As a Civil Engineer, I cannot forget the lesson I learned in surveying: to set a proper foresight one must first focus on a backsight, then reverse the telescope and set a point ahead in the course to be followed.

As we take a backsight on the course we have pursued, we see

*President of Northeastern University, Boston, Mass.

that during the last one hundred years scientific and engineering schools have multiplied until now we have some one hundred and fifty-eight accredited colleges of engineering in this country, and a large number of technical institutes; applied science has created one new industry after another, and brought new techniques, new jobs, new comforts and new conveniences; hygiene, medicine, and surgery have made enormous strides until the average span of life has increased from forty years to at least sixty-five years; speed in transportation has increased until jet-propelled planes can leave Boston at sunrise and arrive in San Francisco two hours after sunrise—as William Rand, President of Monsanto Chemical Company, said in an address at Northeastern University: "Racing dawn across a continent."

As we look about us, we see the constantly expanding stream of more and better goods and services which has been poured into the lap of the average American; the ever-advancing level of living which we have come to enjoy in the march from the one-room log cabin to the modern home; and the magnificent opportunities in this country today for everyone to improve his station in life. Then we realize that "America's progress during the past one hundred years—the rise in individual well being, in wealth, in income, in security, in the scale of living—has been one of the marvels of mankind."

But we have become so accustomed to material comforts that we take them for granted. We assume that they can be maintained by merely increasing production, or by empowering the federal government to grant more and more subsidies, or by developing new and better sources of energy and power.

If we look for the reasons why this nation enjoys the present high standard of living, we see that they are not due to our material resources alone but to their development and use by the people themselves. We see that these things have come about because of the character traits of our people, their fervent desire to be free and independent, their vision and courage at work in a country rich in raw materials.

When we view the triumph of science in producing synthetic products to supplement and improve the materials of nature, in producing the modern miracles of radio, radar, and atomic energy, we come to believe that American genius can produce the knowledge and the know-how to meet any need and to solve any problem which may confront us. In fact, as a result of one success after another, we have been prone to feel that the advancement of the human race is inevitable, that the pathway may be difficult, halting, slow, and at time bloody, but nevertheless ever onward and upward.

It would be easy to look ahead to days of more comfort when by simply pushing more buttons, electronic devices would wake us, dress us, serve us breakfast, hand us the morning paper, take us to the station and put us on the train; when atomic energy in minute quantities will furnish us light, heat, and power—no more coal to shovel, no more empty oil tanks, no more lighting problems—a blessing to home owners. These, and an endless number of other improvements are more of the developments which have already caused us to assume that progress will never cease.

We have, however, come suddenly to see that progress is not necessarily inevitable, that man has learned so much about the manipulation of material things and at the same time gained so little control over human behavior that he is on the verge of destroying himself. We have penetrated the material universe in the last one hundred years but all is not going well.

As we look ahead, we must realize that although we can look to science to find out how the universe works, we can never expect science to find for us why the universe exists, or to explain the Master Mind which directs its working or to determine for us its ultimate destiny.

Although we have waged two world wars to "make the world safe for democracy," we are still searching for some magic formula to cure all of our economic, political, and social difficulties. We need more knowledge of world affairs, a better grasp of our complicated political and economic systems, more study of the social sciences, of man and his relation to the universe. We see that the average man is conscious of the material wealth of this great country, that he has an increasing desire for an equal division of what has already been produced, but that he has to an alarming degree a decreasing desire to work to produce more of the good things of life. What he does not see is that the enduring satisfactions of life do not come from a division of material wealth, from less work and more pay, or from getting something for nothing, but rather from individual achievement. He should cease looking outside himself for the magic which he seeks.

He needs to be reminded, as perhaps do most of us at times, that the growth of this country has been made possible through that great reservoir of hidden assets within the heart and mind dedicated to worthy ends and made to bear fruit. We all need to realize that our society as a whole can be no better than the quality of its individual parts.

We as individuals need to regain something of the vision, determination, willingness to work, and devotion to high ideals which our forefathers possessed—something of the qualities which are the foundation stones on which America was built, then use them to build for tomorrow.

How pertinent is the statement of Robinson Jeffers, "Lend me the stone strength of the past, and I will lend you the wings of the future."

One of our brightest rays of hope for the future comes from the fact that many of our great scientists agree that—and I quote from one of them:

> "Science dominated by the spirit of religion is the key to progress and the hope of the future. . . . The most important thing in the world is a belief in the reality of moral and spiritual values."

With such an attitude of mind, we can be sure that constructive forces are at work in our laboratories.

Another encouraging outlook for the future is the advance of education in America, the placing of emphasis on the mental abilities of all our people regardless of social, racial, or economic condition. We have come to realize that talent is where you find it just as it was in the day of Thomas Jefferson when he said, referring to the State of Virginia:

> "We hope to avail the State of those talents which nature has sown as liberally among the poor as the rich, but which perish without use, if not sought for and cultivated."

We can also look with hope to the influence of those thousands of returned veterans from World War II who have proved in so many of our colleges and universities, as they have at Northeastern University, that they are in general an earnest, sincere and determined group of young men and women whose mature outlook and social realism are an asset to their communities and their country.

As David Lilienthal said recently:

"What goes on in people's minds, and in their hearts, is more important in determining the fateful future than what goes on in laboratories and production centers."

As we look ahead to a better tomorrow, let us not fail to discover and develop the assets to be found in the mental and emotional capacities of our young people today, and guide them into the proper channels for maximum personal development and social usefulness. Above all, in helping our young people develop their native intelligence, let us inculcate in them the idea that there is no substitute for sincere, earnest devotion to the work at hand, that persistence and determination are still the touchstones to success, that holding fast to a planned course of action is the road to achievement.

The future is fraught with trials and difficulties but in adversity there is strength. The future is before us; it is alluring; it is brimful of challenge and opportunity.

As we celebrate this Centennial of the Boston Society of Civil Engineers, let us realize that there is nothing more vital and more important in training for the future than your home and mine, for—

"As long as there are homes where fathers come at close of day,
As long as there are homes where mothers plan and children play,
As long as boys and girls are taught to love the truth, the right—
So long our cities will survive the years, outlast the night.

As long as there are homes where beauty dwells and books are read,
As long as there are homes where kindness reigns and prayers are said;
Although wars fling hatred on the world and nations grope,
With homes like these, and children waiting there, we still can hope."

CENTENNIAL HISTORY OF THE BOSTON SOCIETY OF CIVIL ENGINEERS
1848 — 1948

BY JOHN B. BABCOCK, 3D, PAST PRESIDENT, B.S.C.E.*

April 26, 1848.—An informal meeting of gentlemen engaged principally in Civil Engineering, having been called by private notification, was held at the United States Hotel in Boston, on Wednesday evening, April 26, 1848, to consider the expediency of taking measures to form a Society, for social intercourse and professional improvement, to be composed of civil engineers and of gentlemen engaged in pursuits kindred to civil engineering. Of about twelve persons invited, there were present only Messrs. J. H. Blake, G. M. Dexter, E. S. Chesbrough, H. S. McKean and W. S. Whitwell.

The meeting was not formally organized. A general conversation took place on the subject of the proposed Society. A conviction that it was desirable to form one, and a willingness to co-operate for that object, was expressed by all present. The determination of the precise means to be used was deferred to a subsequent meeting which it was supposed would be more fully attended.

After a light supper the meeting adjourned to meet at the same place on Monday evening, May 8th. H. S. M. [H. S. McKean.]

This informal gathering of five civil engineers of Boston at the United States Hotel marked the first successful endeavor of engineers on this continent to unite for the advancement of the profession and the improvement of its members. Their sincere conviction of the desirability of such an organization and their willingness to cooperate to attain that end are clearly expressed in the record above. At subsequent meetings, in which additional persons participated, the constitution and by-laws were adopted, and on July 3, 1848, was held the first regular meeting of the Boston Society of Civil Engineers—*the oldest engineering society in America!*

Four years later the American Society of Civil Engineers and Architects was established in New York, and in 1869 the Civil Engineers Club of the Northwest (now Western Society of Engineers) was founded in Chicago.[1]

*Professor of Railway Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

[1] "The Boston Society of Civil Engineers and its Founder Members" by John B. Babcock, 3d, Jour., B.S.C.E., July, 1936 includes a brief history of the formation of these societies, the Institute of Civil Engineers (London) and the Société des Ingénieurs Civils de France, which was founded a few months before our Society.

The following officers were elected: *James F. Baldwin,*[2] president; *George M. Dexter,* vice president; *John H. Blake,* secretary; *William P. Parrott,* treasurer; and *Joseph Bennett, Ellis S. Chesbrough, James Laurie, Samuel Nott,* and *William S. Whitwell,* directors.

The desirability of having quarters where meetings could be held and a library established was recognized at the outset, and a room was leased in Joy's Building on Washington Street at $100 per year. A Library Committee was appointed and appropriations made for the purchase of books and periodicals. *Joseph Bennett* later became librarian, an office provided under the by-laws adopted when the Society was incorporated in 1851. Papers presented before the Society were copied neatly in a bound volume, which was available in the library. Considerable attention was also given to the collection of plans, models and specimens of interest to the members. The Society maintained this room until January, 1853, when new quarters were established at 11½ Tremont Row, jointly with the New England Association of Railroad Superintendents.

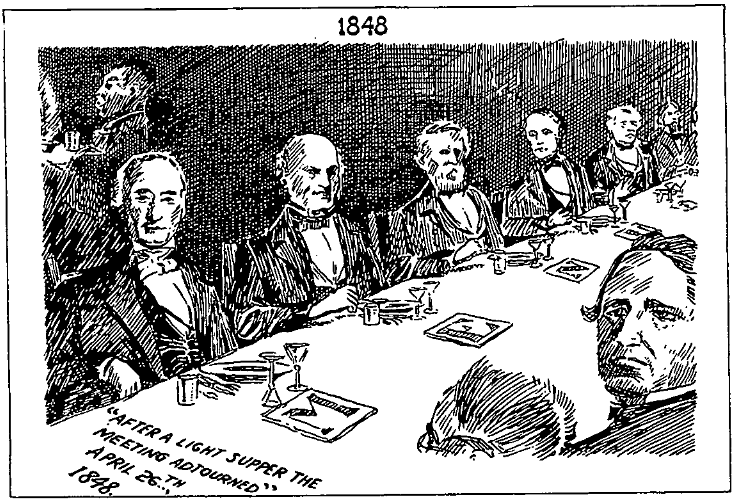


FIG. 1.

Artist's conception of the informal meeting held at the United States Hotel in Boston on April 26, 1848 to consider the formation of a Boston Society of Civil Engineers—originally drawn for the Menu of the Annual Dinner in 1895 it was used again on the Centennial Banquet Menu, April 21, 1948.

[2]Membership in the B. S. C. E. is identified by italics in the text.

James Laurie presented the first paper before the Society on the "Coal and Iron Trade of Great Britain and United States." This was published in the *Mining Journal and American Railroad Gazette* with the editorial comment that "judging from the paper of Mr. *Laurie,* we may look for valuable contributions from this Boston Society to the cause of science and general knowledge, and we rejoice in its existence among us." It is an interesting fact that *Laurie,* a founder member of both the Boston Society of Civil Engineers and the American Society of Civil Engineers, gave the first paper in each.

FOUNDER MEMBERS OF THE BOSTON SOCIETY OF CIVIL ENGINEERS*

Samuel Ashburner (1816-1891)	Waldo Higginson (1814-1894)
James Fowle Baldwin (1782-1862)	Isaac Hinckley (1815-1888)
Joseph Bennett (1814-1875)	Eben Norton Horsford‡ (1818-1893)
John Harrison Blake (1808-1899)	Josiah Hunt (1818-1874)
Simeon Borden (1798-1856)	Martin Brimmer Inches (1820-1893)
Uriah Atherton Boyden (1804-1879)	Samuel Francis Johnson (1821-1883)
Ellis Sylvester Chesbrough (1813-1886)	James Laurie (1811-1875)
John Childe (1802-1858)	Henry Swasey McKean (1810-1857)
Marshall Conant (1801-1873)	Samuel Nott (1815-1899)
Franklin Darracott (1820-1895)	George Alanson Parker (1822-1887)
William Lee Dearborn (1812-1875)	William Pearce Parrott (1810-1868)
George Minot Dexter (1802-1872)	Thomas Willis Pratt (1812-1875)
Sereno Dwight Eaton (1823-1899)	Theophilus E. Sickels (1822-1885)
Robert Henry Eddy (1812-1887)	Lucian Tilton (1811-1877)
Samuel Morse Felton (1809-1889)	William Scollay Whitwell (1809-1899)
James Bicheno Francis (1815-1892)	Thomas Scott Williams (1812-1874)
Charles Haynes Haswell† (1809-1907)	

*Includes all members of the early Society.
†Corresponding Member. ‡Honorary Member.

Many of the papers were on railroads and hydraulics, fields in which most of the members were engaged. Locomotive boiler explosions were distressingly frequent in those days, and we find committee reports to the Society on explosions of the locomotives "Taghconick," "Piscataqua" and "Erie"; these reports were printed in full in Boston newspapers. Other railroad papers included "A Railroad to the Pacific," by Mr. P. P. F. Degrand, a Boston railroad broker; reports of railroad surveys with detailed estimates; and a treatise on "Useful Formulae Adapted to Locating and Constructing Railroads," by *Simeon Borden.*

Boston's first water supply was then being built, and papers on that project included "Construction of Beacon Hill Reservoir" and "Mode Adopted for Carrying Water to South Boston," by *Whitwell*; an excellent one on "Contracts," by *Chesbrough*; and "Use of Lead for Service Pipes," by *Blake*. *Borden* exhibited the base-line measuring apparatus which he had designed and used on the Trigonometrical Survey of Massachusetts, and *Conant* demonstrated his "Solar Attachment" for a compass.

By 1850 the Cochituate Aqueduct was completed, and within a few years the amount of railroad construction in New England had diminished. The middle west, however, was developing rapidly, and civil engineers were in great demand. It is not surprising to find that many of the members left Massachusetts to take advantage of these opportunities. Before long *Childe, Eaton, Felton, Hunt, Johnson, Laurie, Parker, Sickels* and *Tilton* were engaged in railroad work outside of New England; *Nott* and *Pratt* were in Connecticut; *Bennett* was in New York; and finally *Chesbrough* left to take charge of the sewerage work in Chicago. For some time those who remained carried on the affairs of the Society, but with a gradually decreasing attendance. Finally it was decided to suspend the activities, at least for a time. *Ashburner* and *Higginson* were appointed to take over the property of the Society, and in 1861 they deposited the library books and the Society's records with the Boston Athenaeum.

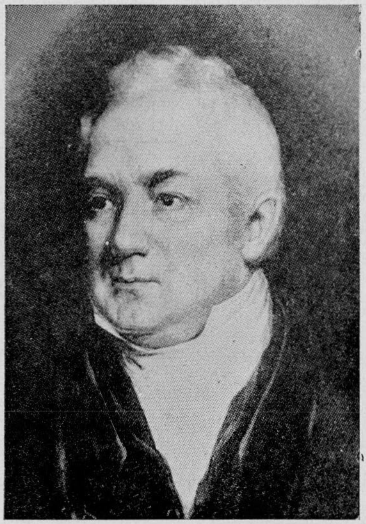
The experience of our Society was much like that of the American Society of Civil Engineers which was founded in 1852 and held meetings for three or four years, then ceased its activities until 1867, when it was revived by *James Laurie,* its first president. In early engineering societies the membership consisted largely of those who had already reached positions of responsibility. Lack of encouragement of the younger men just entering the profession to join and take an active part in the proceedings was probably one of the reasons for the failure of these societies to become stronger in their early years. In the case of our own Society we shall see that a new group of young engineers, with the advantages of technical education and training, was to revive the organization, reestablish the library, and so conduct its affairs that today it occupies a high position in the engineering world!

Education and Training of Early Civil Engineers

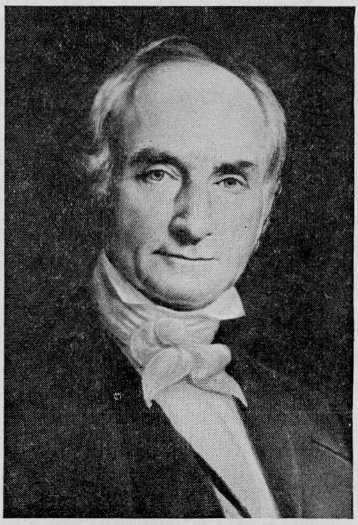
Opportunities for formal education in civil engineering before 1850 were very limited. In fact, Professor *Horsford,* who was associated with the Society as an honorary member, was the only one of this group who had a degree in civil engineering (Rensselaer, 1838). *Parrott* graduated from Norwich University in 1825, where he studied mathematics and the natural sciences, and probably obtained some knowledge of civil engineering. Captain *John Childe,* a graduate of the United States Military Academy, received an excellent grounding in mathematics and science as well as some engineering training.

The middle of the nineteenth century marked the beginning of several well-known scientific and technical institutions and the establishment of civil engineering courses in existing colleges. The Lawrence Scientific School (at Harvard) and the Sheffield Scientific School (at Yale) were both organized in 1847. Courses in engineering were established at Union College in 1845 and at Brown University in 1849.

Loammi Baldwin,[3] often referred to as "The Father of Civil Engineering in America," was responsible for the sound practical training received by many civil engineers in New England. Although originally planning to become a lawyer, his interest in the natural sciences soon convinced him that he should devote his talents to the then little-known profession of civil engineering. After a trip abroad to inspect the public works of Europe he opened an office in Charlestown, Mass., and in the short span of his professional career (less than thirty years) he became the most noted civil engineer of that era.



Loammi Baldwin
1780-1838



James F. Baldwin
1782-1862

FIG. 2.

[3]Son of Colonel Loammi Baldwin, builder of the Middlesex Canal from Boston to Lowell, from whom the "Baldwin" apple received its name.

He took into his office as students a number of young men whom he trained in physics, mathematics, surveying and kindred subjects. These students or apprentices also served as assistants in the field and office as their training progressed. Among these were *Boyden, Dexter, Eddy, Felton, Higginson, Johnson, McKean* and *Parker*. *Samuel M. Felton,* while studying civil engineering there, served as an instructor of mathematics and the sciences. At Loammi Baldwin's death, he took over the office and some of the younger men remained with him as students. Although his death occurred a decade before the B.S.C.E. was organized, any history of the Society would be incomplete if it failed to give to Loammi Baldwin a large measure of credit for his influence on the civil engineering of that formative period.

Most of the other members of the founder group had the equivalent of a high school education, after which they engaged in civil engineering work and gained their knowledge of the profession through practical experience supplemented by earnest study on their own part. It is an interesting fact that the two men who became most prominent in the field of hydraulics and sanitary engineering, and served as presidents of the American Society of Civil Engineers, received almost no schooling beyond the elementary grades—these men were *Francis* and *Chesbrough*![4]

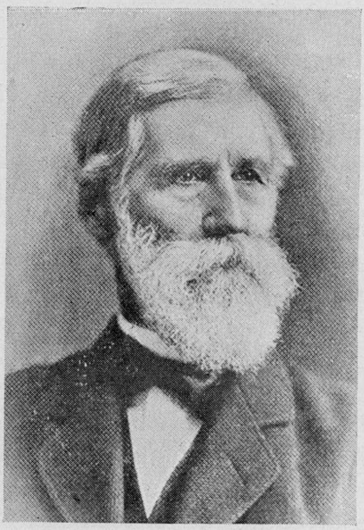
Opportunities for Civil Engineers in 1848

Although the opportunities for obtaining a civil engineering education, as we now conceive it, were limited, the demand for men capable of carrying out engineering projects was great. The era of canal construction had ceased abruptly with the advent of the railroad. In 1825 Loammi Baldwin had reported on a proposed canal from Boston to the Hudson River, but three years later all thought of a canal was abandoned, and his brother, *James F. Baldwin,* was engaged to make surveys for a railroad across the State. Within the next two or three years charters were granted for railroads from Boston to Lowell, Worcester, and Providence; by 1835 these three lines were in operation. This intensive railroad development provided a fertile field for employment, and at least twenty-eight of the thirty-one regular members of the Society were on railroad work at some stage in their careers. At least ten of them devoted their lives to it, occupying po-

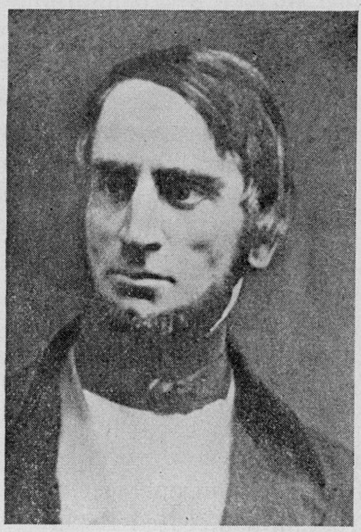
[4]See p. 374 for education and training of civil engineers in the period following the reorganization of the Society in 1874.

sitions of importance in railroad engineering, operation and management (see p. 310).

The development of Boston's first public water supply is closely associated with the Society's early life. For twenty years there had been agitation for a public supply. Loammi Baldwin and later his brother, *James F. Baldwin,* recommended Long Pond as a source, while others, including *R. H. Eddy,* advocated near-by ponds north of Boston. Finally, in 1846, the Cochituate gravity scheme was adopted and *James F. Baldwin* named as one of the commissioners. *Chesbrough* was made chief engineer of the aqueduct section from



Ellis S. Chesbrough
1813-1886



William S. Whitwell
1809-1899

Fig. 3.

Framingham to the Brookline reservoir, and *Whitwell* was chief engineer of the section from Brookline to Boston, which included reservoirs at Beacon Hill and South Boston and the distribution system. *Williams, Sickels* and *McKean* served as resident engineers on this project, and *Conant* was an assistant. On October 25, 1848, a celebration was held on Boston Common when the water was turned on at the fountain in the Frog Pond and rose "in a strong column, 6 inches in diameter, increasing rapidly in height, until it reached an elevation of 80 feet" (see p. 323).

Others were engaged in the development of water power for the growing textile industries on the Merrimack River. With the entry of the civil engineers of this period, rapid strides were made in the science of hydraulic engineering; and New England will always be noted for its celebrated hydraulicians, among the first of whom were *Francis* and *Boyden* (see p. 345). Other activities were taking place in the cities—land and water-front developments, roads and bridges, and the construction of gas works. Many opportunities existed for civil engineers to become associated with industrial enterprises, and in their later years a number of them were eminently successful as presidents of railroads and street railways, fire insurance companies, steel plants, water power and land development projects, and manufacturing and commercial companies.[5]

"JUNIOR" B.S.C.E. OF 1873

The early Society had ceased its activities and deposited its library and records with the Athenaeum in 1861. For the next decade no formal steps were taken by civil engineers in Boston to meet together for the discussion of professional matters. The Massachusetts Institute of Technology, incorporated in 1861, had postponed its opening during the Civil War, but in 1865 classes were started and the first students graduated in 1868. A new generation of civil engineers was becoming established in Boston. One of these was *Ernest W. Bowditch,* M.I.T. 1869, who had opened an office as topographical engineer and surveyor. On May 24, 1873, he wrote to about forty young men in the vicinity of Boston proposing "to form a junior engineers' association to meet at certain times and places for the purpose of consulting and discussing whatever topics of interest may be suggested, connected with engineering."

In response to this call, twenty-six persons met at M.I.T. on May 30, 1873 and agreed to form a Society, the name of which was first suggested as the "Boston Engineers' Club". At a second meeting, on motion of *Desmond FitzGerald,* the name of *"Boston Society of Civil Engineers"* was adopted. With the characteristic enthusiasm of youth, a constitution and by-laws were adopted and on that same day, the new society was under way with the following officers: president, *Desmond FitzGerald*; vice presidents, *Henry Manley* and *Ernest W.*

[5]The professional biographies of the thirty-three founder members of the Society are given in "The Boston Society of Civil Engineers and its Founder Members" by John B. Babcock, 3d, Jour., B.S.C.E., July, 1936.

Bowditch; secretary, *George S. Rice*; and treasurer, *Robert H. Richards*. This was indeed a young group of men. Of the sixty-two names signed to the constitution nearly half had attended M.I.T., which had graduated its first class only five years before.

The Executive Committee was instructed to determine the steps necessary "to render the society legally capable of holding property and of having an exclusive right to its name." It was soon learned that a society bearing the same name, which had been incorporated in 1851,[6] still had a legal existence—although then inactive. Prompt steps were taken looking toward a "union of the societies and possession of literary property of the corporated society."

Contact was made with the members of the early Society, a few of whom were still living near Boston. A meeting was held on April 27, 1874 at which *Francis, Higginson, Darracott, Pratt* and *Nott* were present. *James B. Francis* was elected president and *Samuel Nott*, secretary. The members of the Junior Society (B.S.C.E. of 1873) were proposed for membership in the incorporated Society, and *Higginson* and *Pratt* were delegated to reclaim the property from the Athenaeum. On June 8, 1874, these members of the Junior Society were elected to membership. Thus was established that direct link which provides our Society with a continuous existence for a century![7]

With the "union" accomplished, the older members retired from office, and the Society was turned over to this young and virile group. *Thomas Doane* was elected president, an office which he held from 1874-80 and again from October, 1880 to March, 1884. The other officers elected were: vice president, *Desmond FitzGerald*; secretary, *George S. Rice* and treasurer, *Clemens Herschel.*

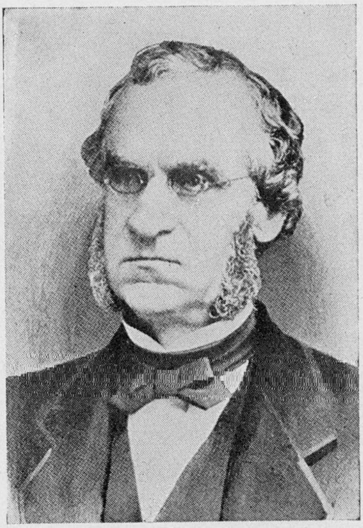
Boston Society of Civil Engineers—1874 to 1948

The foregoing account of the early Society from 1848 to 1874 has been condensed from the author's paper "The Boston Society of Civil Engineers and its Founder Members."[8] The chronicle of the next 75 years of the Society's history must of necessity be presented in a different manner. To describe the professional and the B.S.C.E.

[6]The original incorporation permitted the Society to hold property up to a value of $20,000; in 1902 this was increased to $200,000.

[7]Some years later it was voted that the names of those, then living, who took part in reorganizing the Society on June 8, 1874, should be listed separately on the membership roll and should be exempt from all dues. One by one death has removed the names from this Roll of Honor. Howard A. Carson, Past President of the Society, who died on October 26, 1931, was the last surviving member of. this group.

[8]Jour., B.S.C.E., July, 1936.



James Laurie
1811-1875

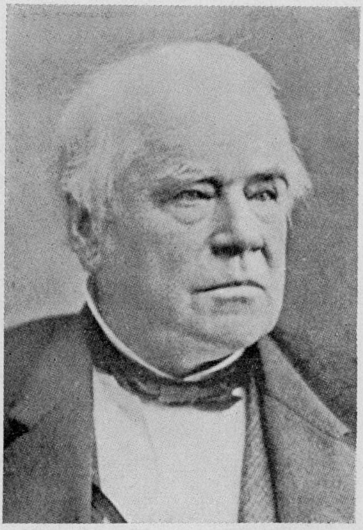
Samuel M. Felton
1809-1889

FIG. 4.

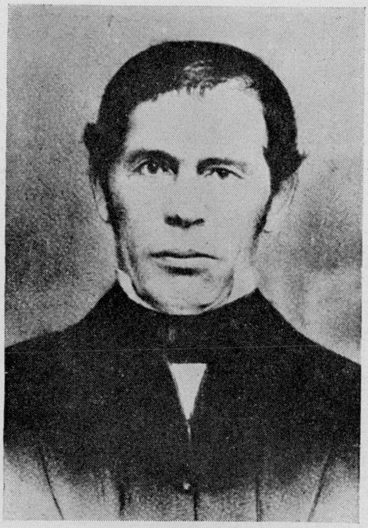
activities of the many hundreds of men who have taken part in the affairs of our Society since 1874 would be a well-nigh impossible task. The contributions of many of these members to the progress of Civil Engineering in America are ably described in the papers presented at the 100th Annual Meeting on March 31, 1948; these are published in this Centennial Journal. Many important contributions to Civil Engineering, which have been made in recent years, are not recorded in these papers since it was decided that the accomplishments of Society members *now living* should not be included. Their notable contributions will be "highlights" of our next Annals!

A chronological record of all the activities of the Society would be so voluminous and repetitious that it would fail to show the growth and development of the Society in true perspective. Instead, the history of the Society for this 75-year period will be traced in topical form, to show the changes which have taken place, the new activities embarked upon, and the status of the Society in this, its Centennial Year. The reader may note the particular attention given to activities of the past two or three decades. The inference might be drawn that this was due to the fact that the author had more personal knowledge of this period or that the recent records were more accessible than the earlier ones. This is not the case! The past twenty-five years or so constitute an era of marked progress in the affairs of the Society. *During this period*—three professional Sections were established; the Society took part in the formation of the Engineering Societies of New England; all but one of the Society's awards and prizes were instituted; the Permanent Fund increased 50 per cent; $25,000 was received for the establishment of the John R. Freeman Fund; four other funds were set up from bequests to the Society; noteworthy reports of the Committees on Boston Subsoils, Rainfall and Run-Off, and Floods were published in the Journal; and "Contributions to Soil Mechanics—1925 to 1940" was published in book form.

The Society has been served by 157 officers[9] since its formation in 1848. Additional hundreds of members have served on committees. All have been loyal workers. Throughout the years many have made notable contributions to the Society through service as officers, committee members and authors of papers. Several have made substantial



James B. Francis
1815-1892



Uriah A. Boyden
1804-1879

FIG. 5.

[9]See p. 398 for "Past and Present Officers of the Society." Forty per cent of these officers are now living, many of them still active in the affairs of the Society.

gifts of books to the library or funds for various Society activities. No attempt will be made to give the names of all such members—the list would indeed be long and the difficulties of making a fair selection too great. The author feels, however, that this history would be incomplete if it failed to mention the names of a few of our past members whose services to the Society were of outstanding character. Perhaps some of our older members, with long background in the Society, will consider this list all too short!

Thomas Doane (1821-1897),[10] who joined the Society June 8, 1874, was elected president August 7, 1874 and served to March, 1880. Following the resignation that year of President *Joseph P. Davis,* who moved to New York, *Doane* again became president, an office which he held until March, 1884. His untiring service had much to do with the sound growth of the Society in those critical years following its reorganization in 1874.

Desmond FitzGerald (1846-1926),[11] who joined the Society June 8, 1874, was elected vice president on September 4, 1874 and served until March, 1877. He was president for two years, 1888-1890. In 1915 he became an honorary member. He was the donor of the medal which bears his name. For many years he made a substantial contribution to the Permanent Fund and left a bequest, the income of which is used for the Desmond FitzGerald Scholarship. In 1898, he delivered the Society's Semi-Centennial Address. For fifty years he took part in Society activities, serving as chairman of many important committees.

John R. Freeman (1855-1932),[12] who joined the Society Jan. 19, 1881, was vice president for two years, 1889-91 and president for the term 1893-94. He was elected an honorary member in 1917. He took great interest in the work of the Society and was particularly impressed with its value to young engineers just starting on their professional careers. In recognition of this he gave $25,000 to the Society for the establishment of the John R. Freeman Fund.

Clemens Herschel (1842-1930),[13] who joined the Society June 8, 1874, was the first treasurer of the reorganized Society, serving from

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[10]Memoir. Trans., Am. Soc. of Civ. Eng., vol. XXXIX, p. 690; also Jour. of Assoc. of Eng. Soc., vol. XXIV, p. 73.
[11]Memoir. Jour. B.S.C.E., vol. XIV, p. 427; also Trans., Am. Soc. of Civ. Eng., vol. 92, p. 1656.
[12]Memoir, Trans., Am. Soc. of Civ. Eng., vol. 98, p. 1471; also Jour., New Eng. Water. Assoc., Vol. XLVII, p. 100.
[13]Memoir, Jour., B.S.C.E., vol. XIX, p. 213; also Trans., Am. Soc. of Civ. Eng., vol. 95, p. 1419.

September 4, 1874 to March, 1880. He was president in 1890-91, and became an honorary member in 1915. Although he moved from Boston in 1879, he always maintained a great deal of interest in the activities of the Society. He established the Herschel Library in 1906 and later provided for prizes in recognition of meritorious papers.

Edward W. Howe (1846-1931),[14] who joined the Society June 8, 1874, served as treasurer for fourteen years, 1892-1906. During this period, the Permanent fund increased from $4000 to $19,000. The Society was fortunate in having as treasurer a man of his interest, capability and sound judgment. He served as president for the year 1907-08. His interest in the Society never halted and he served ably on committees for many years after his term as president. He left a bequest, the income of which is devoted to the Society and its membership.

Henry Manley (1841-1919),[15] who joined the Society June 8, 1874, was treasurer for twelve years (1880-1892). He served as president for the year, 1892-93. Following his term as president, he was a director from 1893 to 1895. In addition to his valuable service as treasurer, another contribution of his to the Society was notable. When the 1st Annual Dinner was held in 1883, *Manley* was responsible for the arrangements; and for the next 25 years he ably carried out the same assignment. He also served on many important committees of the Society. He presented a valuable paper on Rapid Transit in 1889.[16]

Samuel Nott (1815-1899)[17] was a Founder Member of the Society on July 3, 1848. He became a director at that time and served to March, 1849, when he was elected secretary and filled that office until the reorganization of the Society in 1874 (although the early Society was inactive after 1861). He was a regular attendant at the meetings and served on numerous committees. As secretary he was in large measure responsible for the affairs of the early Society. After the reorganization he continued as a regular member until 1891 when he became an honorary member. His last meeting with the Society

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[14]Memoir, Jour., B.S.C.E., vol. XIX, p. 362; also Trans. Am. Soc. of Civ. Eng., vol. 96, p. 1495.

[15]Memoir. Jour., B.S.C.E., vol. VII, p. 223; also Trans. Am. Soc. of Civ. Eng., vol. 87, p. 1387.

[16]In this paper he said "I would let no train be stopped and turned around in the central part of the city. For instance, let trains made up at South Braintree run through the city to Reading and vice versa. Another train made up in Somerville might run through to Dedham". Nearly 60 years later, the report of the Legislative Commission on Rapid Transit for Metropolitan Boston made similar recommendations.

[17]Memoir, Jour., B.S.C.E., vol. XXIII, p. 212; also Jour., Assoc. of Eng. Soc., vol. XXIV, p. 227.

was at its Semi-Centennial; at that time *Desmond FitzGerald* paid high tribute to *Nott's* devoted service to the early Society.

S. Everett Tinkham (1852-1921),[18] who joined the Society on September 18, 1878, was elected secretary on April 21, 1880 and served until December 20, 1882. He again became secretary on May 18, 1887 and served until his death on April 21, 1921. How well he filled that office for the entire 37 years is shown by the records! In his tribute to *Tinkham's* service to the Society, *Desmond FitzGerald* wrote: "In all the wanderings of the Society, from the time when the library was kept in a single dry-goods box to the days of its present magnitude, Mr. *Tinkham's* cheerful and cordial interest were ever exerted for the advantage and enlargement of the Society. . . . The Society, in its chequered career, has had many officers and members who have contributed to its usefulness and renown, but among them was one whose name leads all the rest, and the good which *S. E. Tinkham* accomplished for the Society will endure as long as the Society exists."

George L. Vose (1831-1910),[19] who joined the Society on November 16, 1881, served as its president for three terms, 1884 to 1887. He became an honorary member in 1896. He took the leadership of the Society upon the retirement from office of *Thomas Doane*. These two men served as presidents for more than the first decade of the Society's life following the reorganization in 1874. Professor *Vose* in addresses before the Society made several notable contributions on the lives of such famous early engineers as Loammi Baldwin,[20] and George W. Whistler, noted railroad builder.[21]

Frank O. Whitney (1851-1936),[22] who joined the Society January 15, 1879, was treasurer for 16 years, 1915-1931, serving in this office for the longest period in the history of the Society. He had been a director from 1894 to 1896. His careful administration of the financial affairs of the Society, his sound judgment and his faithful service on an arduous task are deserving of high praise.

Attention has been called to the fact that only one of the founder members (1848) had a degree in civil engineering and only two or

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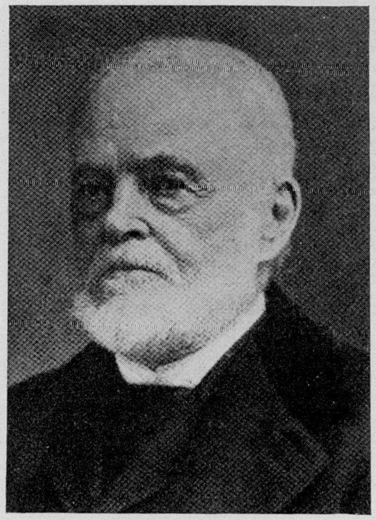
[18]Memoir. The October, 1921 B.S.C.E. Journal (vol. VIII) was devoted to papers in memory of Mr. Tinkham; also see Trans., Am. Soc. of Civ. Eng., vol. 86, p. 1704 and Jour., New Eng. Water. Assoc., vol. XXXVI, p. 318.

[19]Memoir. Jour., Assoc. of Eng. Soc., vol. XLVI, p. 145.

[20]"A Sketch of the Life and Works of Loammi Baldwin," Jour., Assoc. of Eng. Soc., vol. VI, p. 11.

[21]"George W. Whistler, C. E.," Jour., Assoc. of Eng. Soc., vol. VI, p. 37.

[22]Memoir. Trans., Am. Soc. of Civ. Eng., vol. 102, p. 1667.



Samuel Nott
1815-1899

S. Everett Tinkham
1852-1921

FIG. 6.

three had received any formal technical education. But with the establishment of two technical schools in 1848, the adoption soon after of civil engineering courses in several existing colleges, and finally with the opening of M.I.T., in 1865, the opportunity for obtaining a civil engineering training had greatly increased. Today there are more than 100 colleges offering accredited[23] courses in Civil Engineering; many of these schools also give graduate work in this field.

Of the 67 presidents of the Society since its reorganization in 1874, at least 50 attended engineering schools, and several others had some form of higher education. Of those serving since 1900, all but 5 or 6 received a formal engineering education. It is interesting to note, however, that neither *Desmond FitzGerald* nor *Frederic P. Stearns* had any technical education; but both rose to the highest rank in the profession and served as presidents of the American Society of Civil Engineers.

Sixteen members of our Society have served as presidents of national engineering societies—12 in the American Society of Civil Engineers; 3 in the American Society of Mechanical Engineers; and

[23]Approved by E.C.P.D. (Engineers' Council for Professional Development).

one each in the American Institute of Electrical Engineers and the American Institute of Mining and Metallurgical Engineers. (*J. R. Freeman* served as president of both A.S.C.E. and A.S.M.E.)[24]

Ours is the first engineering society in America to observe its Centennial Anniversary. This fact made it seem worthwhile to delve into the records in some detail. It is true that few of our members will be interested in all phases of the Society's history but it seemed best to make it fairly complete for future reference. The author realizes that some significant facts may have been overlooked in scanning such a large amount of material but it is hoped that their number is few.

As stated earlier the subject is presented under those topics into which the Society's activities may be logically divided. Cross-references are used to avoid needless duplication. The order in which the topics appear is somewhat arbitrary and is not an indication of their relative importance.

MEMBERSHIP

The Constitution and By-Laws adopted in 1848 provided for grades of Member, Corresponding Member and Honorary Member. In the early Society, the membership included thirty-one active Members, one Corresponding Member and one Honorary Member.[25] The 1875 By-Laws of the reorganized Society provided for the same grades. By 1890 the grade of Corresponding Member had been eliminated, and a grade of Associate had been added to include "other persons interested in the objects of the Society and desirous of being connected with it."[26]

In his presidential address in 1909, *Joseph R. Worcester* laid considerable stress on the desirability of making the Society of more interest to the young engineers on whom the responsibility of carrying on the profession would later rest. It was probably due to the interest aroused by his address that a committee was appointed the following year to consider the revision of membership grades. On June 15, 1910 the Society adopted a revised Constitution and By-Laws which pro-

[24]A.S.C.E.—James Laurie, E. S. Chesbrough, J. B. Francis, Alphonse Fteley, Desmond FitzGerald, F. P. Stearns, G. F. Swain, E. L. Corthell, Clemens Herschel, F. S. Curtis, J. R. Freeman, H. P. Eddy. A.S.M.E.—J. R. Freeman, I. N. Hollis, C. T. Main. A.I.E.E.— D. C. Jackson. A.I.M.E.—R. H. Richards.

[25]The names of the Founder Members (1848) are shown on p. 362.

[26]The number of Associates has never been large, seldom over 2 per cent of the membership; on March 31, 1948 there were only 3 members in this grade.

vided for a grade of Junior. This grade has been continued, with minor changes in age limits, to the present and has proved beneficial in attracting younger men to join the Society. In 1932 the grade of Student was added.

In the year 1923-24, the By-Laws were amended as follows: "A member of any grade who has paid dues for forty years, or who has reached the age of seventy years and has paid dues for thirty years, shall be exempt from all further dues."[27]

During the year 1947-48, there were eight Honorary Members on the rolls of the Society.[28] At the time of the Centennial Meeting (March 31, 1948) our senior member was Prof. *C. Frank Allen*, Past President and Honorary Member, who joined the Society on March 24, 1875. It is with deep regret that we record his death on June 6, 1948 after a membership of almost three-quarters of a century. (Professor *Allen* was also the senior member of the A.S.C.E.).[29]

About 60 members of the Junior Society (B.S.C.E. of 1873) became members of the incorporated Society on June 8, 1874. The membership list shows 75 members in 1875 and 90 in 1879. The hundred mark was passed in 1882. In 1888, there were two hundred members. At the time of the Semi-Centennial (1898) the Society had nearly 500 members. The membership increased steadily until 999 were enrolled at the beginning of World War I. Following a decrease during the war period, it increased again and reached its maximum enrollment of 1065 in 1930. During the serious depression of the 30's, followed by World War II, the enrollment was again reduced. At the Annual Meeting on March 31, 1948 the Society's membership was 782, but on July 3d (the official Centennial date) it was over 800.[30]

Meetings

It would be impossible to present an adequate summary of the 800 (more or less) meetings of the main Society between 1874 and 1948. Only some of the "high lights" will be attempted!

In the early years, part of each meeting was devoted to verbal

[27]In the year 1947-48 seventy-two members (nearly 10 per cent of the total enrollment) were exempt from dues under this provision.

[28]Dr. Karl T. Compton, Prof. C. Frank Allen, Prof. Charles M. Allen, Arthur W. Dean, Charles R. Gow, Arthur T. Safford, Prof. Charles M. Spofford and Charles W. Sherman. On March 24, 1948, the following were elected to Honorary Membership: Prof. Dugald C. Jackson, Sanford E. Thompson and Edwin S. Webster.

[29]Our senior member is now Frederick W. Bateman, who joined the Society on March 21, 1888 and has maintained continuous membership since that date.

[30]Those residing over 30 miles from Boston are classed as non-resident members and pay lower dues. There are now about 165 of these included in the membership.

reports on recent articles in American or European technical journals. The rest of the program included a talk or paper on some engineering project of current interest.[31] Excellent papers presented before the Society were soon (1881) being published in the Journal of the Association of Engineering Societies. During the next thirty years the volumes of that Journal contained many valuable papers from the Society (see p. 385). Since 1914 they have been published in the B.S.C.E. Journal.

Regular Meetings. The Society has always held regular monthly meetings except during the summer.[32] For many years informal meetings were held in the Society's rooms on special topics or for the discussion of papers presented at previous regular meetings. But with the establishment of a complete program of Section meetings devoted to topics in specialized fields, the holding of extra meetings of the main Society has practically ceased. Each year at least one of the Society meetings is held jointly with a Section which sponsors the program.

Annual Dinner and Annual Meeting. The First Annual Dinner was held at Young's Hotel on March 21, 1883. *Henry Manley* was appointed a committee of one to make the arrangements. In 1907, when the Twenty-Fifth Annual Dinner was held, a gold watch and chain was presented to *Manley,* who had arranged every one of these twenty-five affairs! For several years, the Annual Dinner and the Annual Meeting were held on separate days, but since 1909, the Annual Dinner (or Smoker) has been held following the afternoon Annual Meeting. The award of prizes is now a pleasant feature of each Annual Dinner. The menus of the dinners in the "good old days" seem almost unbelievable at the present time—and the price was only \$2.00![33]

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[31]In the annual report of the Board of Government for 1875-76, attention was given to the question "whether to make the meetings altogether informal and conversational, and so run the risk of wasting time, or of descending to personal discussions, or whether to confine them mainly to formal papers which shall be read and then opened for discussion simply, with the chance of stiffness and inutility, or whether a middle course shall be adopted."

[32]Regular meetings have been held on the 3d Wednesday of the month throughout most of the period since 1874. The January meeting was later moved to the 4th Wednesday to avoid conflict with the A.S.C.E. Annual Meeting at New York; the September meeting was also changed to the 4th Wednesday a few years ago. For several years around 1890, the meetings were scheduled at 19:30 o'clock (instead of 7:30 p.m.). The clock now in the Society rooms has an ingenious dial in which the figures of the hours can be arranged to show the time on either the regular 12-hour or on the 24-hour system.

[33]Young's Hotel, March 6, 1889. MENU: Oysters on Deep Shell; Soup: Mock Turtle—Consommé Brunoise. Fish: Chicken Halibut, Sauce Hollandaise; Removes: Sirloin of Beef—Mallard Duck—Roast Philadelphia Chicken—Leg of Mutton, Caper Sauce; Entrees: Potted Pigeon, Andalouse—Chicken Croquettes, Sauce Supréme—Banana Fritters, Glacé Curacao—Vol au Veut of Oysters à la Poulette—Spaghetti Monte Carlo—Lobster Cutlets à la Cardinal. Sweets: Charlotte Russe—Wine Jelly—Lemon Méringues—Tipsy Cake—Frozen Pudding—Biscuit Glacé; Dessert: Oranges—Bananas—Apples—Nuts—Raisins—Figs—Ice Cream—Sherbert—Coffee.

For nearly a half century the President has delivered an address at the Annual Meeting. It became such a regular custom that it was included *as a requirement* in the 1910 revision of the By-Laws.

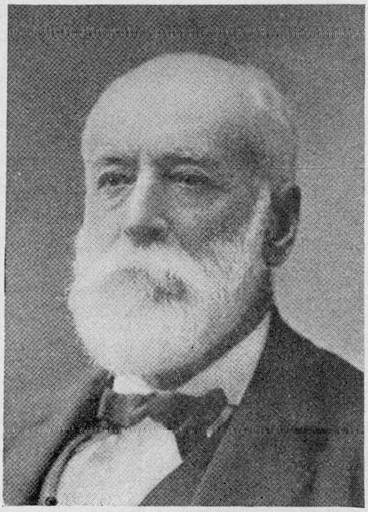
Semi-Centennial Celebration. The Hotel Vendome was the scene of our Semi-Centennial Celebration on November 11, 1898. Following a reception by the officers and their wives, President *Howard A. Carson* spoke on "Glimpses of Boston Fifty Years Ago." *Desmond FitzGerald,* Past President, then gave the Historical Address in which he traced the life of the early Society, its reorganization in 1874 and its activities during the succeeding quarter century. His address paid tribute to many of the deceased members who had been active in the Society during that period. After *FitzGerald's* memorable address, a collation was served, followed by music and dancing.[34]

Student Night. A high spot in the program every year is Student Night. On April 5, 1911, when *Charles T. Main* was president, the first of these events took place. Civil Engineering students at Harvard, Tufts and M.I.T. were guests of the Society and about 350 attended. *George B. Francis,* Past President, gave an illustrated talk on "The Engineering Features of Pennsylvania Terminal Station in New York City." This affair has been carried on each year since then.[35]

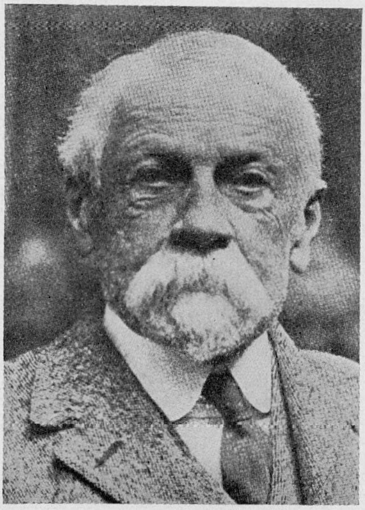
Social Activities. "After a light supper the meeting adjourned" (from minutes of informal meeting, April 26, 1848). The habit of eating together on the evenings of the meetings was thus established 100 years ago—a custom happily preserved! When the Society quarters were at the Boston & Albany Railroad station (1885-89), the members dined together at the restaurant there (at 25% below list prices) before the meeting. Again when located at the American House there was opportunity to continue this custom. For many years after the Society moved to Tremont Temple in 1896, tables were reserved on meeting nights at Marston's restaurant for members desiring to eat together. In 1914 a Social Activities Committee was appointed to arrange dinners preceding the meetings at the Boston City Club and at various hotels. Beginning in 1919, the Committee provided buffet suppers in the Society rooms or in Chipman Hall, Tremont Temple. This met with much favor and was continued until 1933. Since then many of the meetings have been held at other locations, but a dinner

[34]The 60th Annual Meeting was held in connection with a summer outing at Bretton Woods, N. H.

[35]It is now held as a joint activity of our Society and the Northeastern Section of the American Society of Civil Engineers with students invited from the Northeastern Section, B.S.C.E. and the A.S.C.E. Student Chapters in the New England Area.



Thomas Doane
1821-1897



Desmond FitzGerald
1846-1926

Fig. 7.

has usually been included in the program. Recently several meetings have been held in the splendid auditorium of the American Academy of Arts and Sciences on Newbury Street. Although facilities are not available for serving a complete meal, the Hospitality (formerly Social Activities) Committee has provided a collation in the library after the meeting. These have been highly successful and have afforded an excellent opportunity for the members to spend a pleasant hour together.

Excursions

Starting in 1885, excursions became a very prominent feature in the Society's program. For the next 30 years, the Excursion Committee arranged about 10 trips each year. They were usually held in the afternoons preceding the regular evening meetings. Some of them included the ladies and concluded with a clambake or other festivity. The average attendance was seldom less than 50, in some years as high as 75. Although most of the excursions were made to construction projects or recently completed work, a number were to industrial plants.[36] The monthly Bulletin of New Engineering Work (1900-13)

[36]Excursions in 1893-94 included: Boston Bridge Works; General Electric Co., Lynn; Lawrence Experimental Station and New Filter; Metrop. Sewerage Works, Deer Island; Brockton

prepared by the Excursion Committee, furnishes an excellent summary of construction activities in Boston and vicinity (see p. 385). From 1886-90, excursions lasting two or three days were made each Fall to points of interest in New England.[37]

Later the interest in such frequent excursions apparently waned and after 1915 no regular Excursion Committees were appointed. Since then the Society has made a good many inspection trips to construction projects of particular interest but they have not constituted a major part of the program. The Sanitary Section usually devotes its June Meeting to an inspection trip.

Sections

Sanitary. Albert F. Noyes, in his presidential address in 1896, suggested the formation of sections or branches within the Society for the discussion of topics of particular interest to individual groups. In 1903, President *George A. Kimball* again urged consideration of this subject. On December 21, 1903, the Board of Government received a petition from fourteen members of the Society to establish, in accordance with the current By-Laws,[38] "a section for consideration of the special subjects relating to sanitary engineering, to be known as the Sanitary Section of the Boston Society of Civil Engineers." This petition was approved and on January 27, 1904 the Board approved the By-Laws which had been adopted by the Section. For 45 years the Sanitary Section has been in active operation and has been a highly important factor in the Society's activities.

The Sanitary Section has appointed a number of committees to study special phases of sanitary engineering. These included such topics as Run-Off from Sewered Areas; Sewerage Statistics; Inverted Syphons for Sewers; Collection and Disposal of Garbage; and Minimum Velocity for Sewers. The reports of these committees have been printed in the Journal.

Structural. No additional sections were formed for about fifteen

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Sewage Disposal Plant; Boston Rubber Shoe Co., Malden; New Public Library and Natural History Rooms; State House Extension; North Packing and Provision Co., and New England Dressed Meat Co., Somerville. Excursions in 1906-07 included: Charles River Basin and Dam; Wonderland Park, (before public opening); Lawrence Worsted Mills; Blake & Knowles Pump Co., Portland (Me.) Stone Ware Co.; Paragon Park; Simplex Pile Driving, N. Y., N. H. & H. R.R.; Submarine Signal Co.; Washington Street Subway. (Where subway and tunnel work was included, members were requested to bring overshoes or rubbers and to wear old hats and coats).

[37]In 1886, to Hoosac Tunnel; 1887, White Mountains; 1888, Newport and Providence; 1889, Lake Champlain; 1890, White Mountains. (In the announcement of one of these trips it was stated that it was "restricted to members and their lady friends only").

[38]Revised at about that time to provide for the formation of Sections.

years. On May 19, 1920, the Board[39] approved the By-Laws of the Designers Section (renamed Structural Section in 1947). One of the objects of this section was to provide for the informal presentation of papers. It was felt that this would provide a better opportunity for the younger members employed as designers to take an active part in the discussions. The programs of this section have been very successful throughout. In recent years with the formation of additional sections in separate fields, its meetings have been increasingly devoted to structural engineering.

Transportation. The Board approved the organization and By-Laws of a Highway Section on May 1, 1924. The name was changed to Transportation Section in 1946, and the scope of its activities broadened to include railways and airports.

Hydraulics. A section devoted to Hydraulics was organized on May 1, 1940. This section was formed to occupy a field in Section activities not previously covered. It was to a considerable extent the result of the wide interest shown in a series of lectures designated as the John R. Freeman Lectures on Hydraulics given in 1939-40 (see p. 389).

Surveying and Mapping. The most recent section is the Surveying and Mapping Section, which was authorized by the Board on April 8, 1947. The activity of this section during the past year has justified the expectations of its sponsors.

Northeastern University. An affiliate section of the Society was authorized at Northeastern University on January 20, 1922. Membership in this section is limited to students, graduates or members of the Faculty of Northeastern University.

Section meetings are usually held in the Society rooms; the average attendance is probably about 45 although it varies considerably depending on the subject. From twenty to twenty-five meetings of the professional sections are held each year; exclusive of the Northeastern University Section which holds its meetings at the University. Joint meetings of two Sections are often held on subjects of mutual interest.

The formation of these sections of the Society has been amply justified. They have added greatly to the strength of the Society as a whole and have been of much value to the individual Section members. Section Prizes (see p. 387) have provided an incentive for the preparation and presentation of papers.

[39]The Board of Government includes the president, two vice-presidents, secretary, treasurer, four directors and the three latest past-presidents. Chairmen of Sections are invited to attend all meetings of the Board.

Society Rooms

The early Society in 1848 established quarters for a library and meeting room in Joy's Building. In 1853 the Society moved to 11½ Tremont Row where quarters were occupied jointly with the New England Association of Railroad Superintendents for several years. With the reactivation of the Society in 1874, a room was obtained at 66 State Street which was used for a short time. In 1876, the library was moved to a room at Wesleyan Hall, 36 Bromfield Street, where the quarters were maintained for nine years.

In 1885 the Society was fortunate in obtaining the joint occupancy with the New England Railroad Club of a room (rent free) at the Boston & Albany Railroad Station. Here for the first time, space was available to provide adequate facilities for library and meeting room. But in 1889, this room was needed by the railroad and the Society was again without a home. For a brief period, it withdrew to M.I.T. Later a room was obtained at the American House where meetings were held. In 1893, a move was made back to 36 Bromfield Street (Wesleyan Hall). Although larger than its previous quarters there, facilities were scarcely adequate for the increased membership and the growing library.[40]

In 1896 the Society moved to Room 715 Tremont Temple, where it has remained for over fifty years. Ample space was then available for the library and reading room and for informal meetings. Since that time the quarters have been enlarged from time to time by the addition of adjoining rooms. The first regular meeting at Tremont Temple was held in Chipman Hall, on May 20, 1896 with an attendance of 318 members and guests. Since 1922, the Engineering Societies of New England have maintained headquarters jointly with the B.S.C.E. in these rooms.

For years it has been the hope of many of the members that the Society might join with other engineering groups in the establishment of a modern clubhouse with ample accommodations for auditorium, library and cuisine facilities. Although a number of plans to accomplish this have been studied, no plan has yet been evolved which provides a satisfactory solution within the resources of the Society.[41] Engineer-

[40]In considering these quarters it was stated that "the noisy Temperance Society, which heretofore occupied the adjoining hall, has moved".

[41]In at least two cases, contributions were solicited toward a proposed permanent quarters and club house. The plans under consideration from 1908-10 resulted finally in the formation of the Engineers' Club of Boston as a private club instead of as a joint activity by engineering groups in Boston.

ing groups in several of the larger cities have been successful in obtaining facilities of this character. In almost every case, however, it has been made possible through a gift of sufficient amount to provide the capital cost of the building and equipment. Is it too much to hope that some benefactor may do the same for the engineers of Boston?

Library

"A library maintained for the use of its members"—this has been included among the objects of the Society in its Constitution for one hundred years! Attention has been called to the small library deposited with the Athenaeum when the activities of the early group ceased. In 1874 these books formed the nucleus of a library for the rejuvenated Society. Its growth since then is indicated as follows: in 1889 there were 600 bound volumes and 900 unbound volumes and pamphlets; 1903, about 5000 volumes including pamphlets; 1914, 7500 bound volumes and 2000 unbound; 1925, 10,500 bound volumes and 3800 pamphlets.

From 1874 until 1896, the various quarters occupied by the Society were small and rather inadequate for the library. The room at the Boston & Albany Railroad Station (1885-1889) apparently provided the only satisfactory library facilities during this period. But when the Society moved to Tremont Temple in 1896, it was believed that the facilities would be ample for many years. But this proved not to be the case. Soon the Librarian reported that space was inadequate. In 1906, the quarters were materially enlarged by the addition of adjoining rooms and the library facilities remodelled. In the ensuing years the shelves again became filled. For about twenty-five years, it has been necessary to make room for new material by progressively discarding older material, particularly those bound periodicals and departmental reports which are used infrequently and are available elsewhere. At the Annual Meeting in 1947 the Library Committee presented a detailed report to the Board of Government with recommendations as to the material which should be maintained permanently, the publications which should be kept for a limited time, and the material, available elsewhere, which might well be discarded from our library.[42] Progress is now being made in carrying out these recommendations.

[42]Jour., B.S.C.E. vol. XXXIV (April, 1947), pp. 133-144.

The importance of securing the latest text and reference books in civil engineering was recognized from the start. Appropriations from current income and from the income of several funds available for library purposes, have been made each year for the purchase of such books. Many have been donated by authors and publishers. In 1922, when the Affiliated Technical Societies of Boston (now Engineering Societies of New England) became joint occupants of the Society's rooms, some books in electrical and mechanical fields were added by the Society and the list of technical periodicals broadened.

Herschel Library. The Society has received many valuable donations of books from its members. The Herschel Library deserves particular mention. In 1906, *Clemens Herschel,* Past President and Honorary Member, presented seventy books to form the nucleus of a special library. Most of these were books about engineers and engineering, or books written by engineers. Mr. *Herschel* donated additional books to this collection during his life and others were received from his estate. This collection is of unusual interest and value.

In 1909 *Harold Parker* presented the Society with 300 volumes from the library of his father *George A. Parker,* one of the founder members. These books are of historical value as they show the developments in civil engineering in the early years of the nineteenth century. In a similar category are a number of books received from the estate of *Charles H. Swan* in 1901. In 1916, the Society received 1100 books from the estate of *Edmund K. Turner.* Many other donations of books and transactions have been received from our members. The Library Committee recommends that some of these scarce and valuable books be placed in an historical collection in our library which will be of increasing interest and value as time passes.

Publications

The papers presented before the early Society were copied in a bound volume which was available to the membership in the Society's library. Although not published by the Society a number of these papers were printed in newspapers and periodicals.[43] The "Reports of Proceedings—September, 1879 to June, 1881" was one of the first publications of the Society. It contained minutes of meetings, annual reports, committee reports and the papers presented before the Society.

[43]A treatise entitled "Useful Formulae Adapted to Locating and Constructing Railroads," originally presented as a paper before the Society by Simeon Borden, was subsequently printed in book form.

Journal of Association of Engineering Societies. In 1881, the Society joined the Engineers' Club of St. Louis, Civil Engineers' Club of Cleveland and Western Society of Engineers in organizing The Association of Engineering Societies. The primary object was to provide a joint publication of the papers and proceedings of the participating societies. Other groups subsequently joined the Association; in 1900 there were eleven member societies. The papers and proceedings of our Society were printed in the monthly Journal of the Association from 1881 until the Society withdrew in 1913 to establish its own Journal.

Bulletin of New Engineering Work. From 1900 to 1906 the Society issued a monthly publication which included notices of meetings and excursions and a special section entitled "Bulletin of New Engineering Work."

Monthly Bulletin. In 1906, the content of the Bulletin was extended to include minutes of meetings, annual reports, library notes, etc. but not the papers presented before the Society. At this time an advertising section was added to help defray the cost of publication. The Bulletin was continued in this form through 1913. The section on New Engineering Work (1900 to 1913) probably furnishes one of the most complete records in existence of civil engineering projects then underway in this area.

B.S.C.E. Journal. In 1913, the Society voted to withdraw from the Association of Engineering Societies and establish its own Journal. In the report of a special committee, attention was called to the fact that in the 10-year period ending in 1912, our Society had furnished nearly one-half of the entire text of the Association's Journal. It was felt that the advantages to the Society of having its own Journal far outweighed the disadvantages of losing the papers presented by other societies. It was also believed that the cost of publishing such a Journal, with the elimination of the Monthly Bulletin, would be less than under the previous procedure.

The B.S.C.E. Journal made its appearance in January, 1914. The first paper was a noteworthy one and set a high standard for this new publication.[44] Ten issues of the Journal were published each year for Volumes I to XX. Since 1934, the Journal has been published

[44]"Boston Foundations" by J. R. Worcester, Past President of the Society. In addition to valuable text material it included an appendix with twenty-six folding plates showing the location and the soil information for many hundreds of borings in Boston, Brookline, Cambridge and Chelsea.

quarterly with an index in the last issue of the year. A card index of the material published in the Journal is available at the Society's library.[45] The Journal contains papers presented before the Society and its Sections, reports of professional committees, items of general interest and the proceedings of the Society and Sections.

No attempt will be made to mention the many excellent papers which have been published. The list is too long and the difficulty of choice too great! Attention should be called, however, to the meritorious papers presented on topics in the field of Soil Mechanics. In 1940, the Society printed a book of 400 pages entitled "Contributions to Soil Mechanics—1925-1940" which contains thirteen papers reprinted from the Journal and one from the New England Water Works Journal.[46]

Several valuable reports by professional committees of the Society have been published in the Journal (see p. 393). The April, 1946, Journal contains the Constitution and By-Laws of the Society; By-Laws of the Sections; and Awards and Prizes of the Society.[47]

Awards and Prizes[48]

Desmond FitzGerald Medal. At a Society meeting on September 15, 1880 it was voted "that the sum of $15 be appropriated to be expended on books as a prize for the best essay read before the Society during the year ending March, 1881". In March, 1881, the Society continued this offer for the ensuing year. However, no records have been found which indicate an award of this prize in either year. Apparently no further consideration was given to the establishment of a prize for nearly thirty years. At the annual meeting of the Society in 1910 it was voted that the Board be requested to consider the advisability of offering an annual prize for the best paper presented to the Society. Past President *Desmond FitzGerald* offered to provide a bronze medal to be given as a prize each year. On December 21, 1910, the Society accepted this generous offer and adopted the proposed rules governing the award of this medal which was designated as the Desmond Fitz-

[45]It is expected that a cumulative index for Volumes I to XXXV (1914-1948) will be printed as a supplement to the Journal at an early date.

[46]This book has been reprinted several times; copies are available at the Society rooms, 715 Tremont Temple, Boston at $2.25 per copy ($2.00 each when three or more copies are ordered).

[47]The Society published a list of members regularly until 1926. The B.S.C.E. members are now listed in the E.S.N.E. Bluebook.

[48]Regulations governing the awards, names of recipients and titles of papers for which awards were made through the year 1945-46 are given in the April, 1946, Journal.

Gerald Medal. These have been awarded for thirty-two papers through the year 1947-48.

Clemens Herschel Award. In 1923, *Clemens Herschel,* a Past President, presented to the Society a number of autographed copies of his book entitled "Frontinus and the Water Supply of the City of Rome" (a translation from the Latin) with the request that the Board award one or more of these books as prizes for papers which have been "particularly useful and commendable and worthy of grateful acknowledgement". These copies were exhausted in 1941, but the Clemens Herschel Fund, established in 1931 as a bequest, now provides for prizes of books. Forty awards have been made through the year 1947-48.

Section Prizes. The Board voted on April 12, 1924 to present a prize for a worthy paper given in each section by a member of that section, "this award to consist of books suitably inscribed." Thirty-nine Section Prizes have been awarded through the year 1947-48 as follows: Sanitary Section, 12; Structural (formerly Designers) Section, 13; Transportation (formerly Highway) Section, 4; Hydraulics Section, 5; Northeastern University Section, 5.

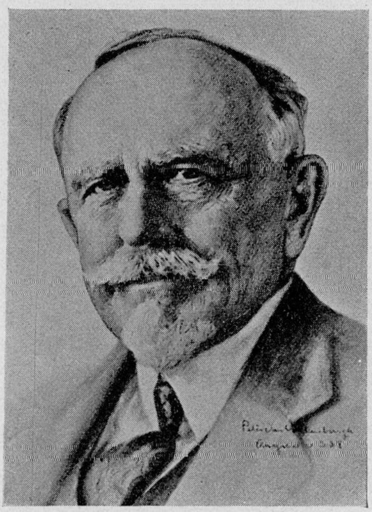
Desmond FitzGerald Scholarship. This award is made to students in Civil Engineering at Northeastern University in memory of *Desmond FitzGerald,* Past President and Honorary Member of the Society, and in keeping with the intent of the donor that the income from the fund "be used for charitable and educational purposes." Thirteen awards were made through the year 1943-44.

Samuel E. Tinkham Scholarship. This fund was established in 1921 at the Massachusetts Institute of Technology from contributions of the membership in memory of *Samuel E. (S. Everett) Tinkham,* who served as Secretary of the Society for thirty-seven years. The income of the fund is used "to assist some worthy student of high standing to continue his studies in Civil Engineering." The value of this fund is currently about $2500.

John R. Freeman Fund

In 1925 *John R. Freeman,* Past President and Honorary Member of the Society, made a gift to the Society of securities amounting to about $25,000 which was established as the John R. Freeman Fund. Similar gifts were made by him to the American Society of Civil Engineers and to the American Society of Mechanical Engineers. The income of this fund is particularly devoted to the encouragement of the younger members. Mr. *Freeman* suggested several uses, such as the payment of expenses for experiments and compilations to be reported to the Society; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to the Society; or establishing a traveling scholarship open to the younger members of the Society for visiting engineering works. A standing Freeman Fund Committee has the responsibility of determining how the income of this fund shall be used.

Clemens Herschel
1842-1930



John R. Freeman
1855-1932

Fig. 8.

Traveling Scholarships. From 1927 to 1938, the Committee awarded Traveling Scholarships to six young men for a total of ten years' study. The scholarships, with one exception, were for study in Europe.

Publications. The Committee has from time to time authorized the use of a portion of the income for the publication of such important reports as those of the Society's Committees on Rainfall and Run-Off and on Floods, and a report on hydraulic laboratories.[49]

[49] "Representative Hydraulic Laboratories in the United States and Canada" by L. J. Hooper, Freeman Scholar, Jour., B.S.C.E., Jan. 1938, Sect. 2.

John R. Freeman Lectures on Hydraulics. A series of lectures on hydraulics was given in 1939. Seventeen lectures were given by Dr. *Kenneth C. Reynolds,* at that time a member of the staff at M.I.T. and in charge of its River Hydraulic Laboratory, and a former Freeman Scholar in Europe. The final lecture was given by Prof. Harold C. Thomas of the Carnegie Institute of Technology. These lectures were limited to members of the Society; the average attendance was 86.

Research. Appropriations have been made for hydraulic research at engineering schools in the vicinity of Boston. Owing to the difficult conditions in the colleges during and immediately following the war, it has not been possible to carry out any of these projects yet.

Capital Funds

The capital funds of the Society had a book value of about $108,000 on March 8, 1948 as shown below:[50]

Permanent	$67,532.80	French	$1,096.23
Freeman	31,959.97	Herschel	1,203.05
Turner	1,037.55	Howe	1,001.69
FitzGerald	2,074.87	Morse	2,000.00

Permanent Fund. On March 15, 1882, the Society voted "that the income of the invested funds and the money received from entrance fees be added to a permanent fund and not used for current expenses." The nucleus of the Permanent fund at that time was a $1200 investment in railroad bonds. The growth of this fund is indicated below; 1890, $3000; 1900, $10,000; 1910, $26,000; 1920, $44,000; 1930, $49,000; 1940, $58,000; 1948, $67,500.[51]

Freeman Fund. On March 19, 1925, *John R. Freeman,* Past President, presented to the Society securities having a value of about $25,000 and yielding an annual income of about $1700 (see p. 387).

Turner Fund. In 1916, the Society received $1000 under the will of *Edmund K. Turner,* the income to be used for library purposes.

FitzGerald Fund. In 1928, a bequest of $2000 was received from the estate of Desmond FitzGerald, a Past President. The will provided for the establishment of a fund, the income to be used for charitable and educational purposes (see p. 387).

French Fund. In 1931, a bequest of $1000 was received from the

[50]The market value on that date was 95.5% of the book value.

[51]The rate of increase since 1920 has been less than in earlier years. With increased expenses, the Society has for a number of years authorized the use of a portion or all of the income of the Permanent Fund for current expenses.

late *Alexis H. French,* Past President, the income to be devoted to the library.

Herschel Fund. In 1931, a bequest of $1000 was received from the late Clemens Herschel, Past President, the income to be used for prizes for meritorious papers presented before the Society (see p. 387).

Howe Fund. In 1933, a bequest of $1000 was received from the late *Edward W. Howe,* Past President. No restrictions were placed upon the use of this money but the Board has recommended that the fund be kept intact, and the income used for the benefit of the Society or its members.

Morse Fund. In 1948, a bequest of $2000 was received from the late *William P. Morse.* The Board has recommended that the income be used for the benefit of the Society or its members.

Relations with Other Societies

Boston's civil, electrical and mechanical engineering groups have long cooperated, informally at first and later as members of the Engineering Societies of New England. The Boston Section of the American Institute of Electrical Engineers was started in 1903 and that of the American Society of Mechanical Engineers in 1909. Meeting notices of these sections were included in the B.S.C.E. publications with a cordial invitation to our members to attend, and electrical and mechanical engineers were invited to our meetings. Joint meetings were often held on subjects of mutual interest. Starting in 1910, an Annual Engineers' Dinner was sponsored by these groups. Following World War I steps were taken to secure closer cooperation between these societies and other technical groups in Boston.[52]

On June 12, 1922 "The Affiliated Technical Societies of Boston" was granted a charter "to bring the technical societies and their members into closer touch with one another for more effective public service, and for the advancement of scientific investigation, education and research." The name was changed to Engineering Societies of Boston, Inc. on June 11, 1929 and to its present name, Engineering Societies of New England, Inc. on June 6, 1934. The first chairman was *Leonard Metcalf,* Past President of our Society, who had taken a prominent part in founding the Affiliation. Nine societies and sections of national societies, with a membership of 3300, became mem-

[52]On November 12, 1921, the Northeastern Section, A.S.C.E., was organized. This section was an Affiliate Section of our Society for a brief period prior to the organization of the Affiliated Technical Societies of Boston.

bers at that time.[53] Arrangements were made for occupancy with the B.S.C.E. at 715 Tremont Temple. These joint headquarters have been continued to the present time. The E.S.N.E. Journal, published monthly except during the summer, contains announcements of the meetings of all the affiliated societies together with matters of general interest to the membership.

The most cordial relations have always been maintained with the American Society of Civil Engineers. Our Society has been invited to take part in many meetings of the national society held at Boston and nearby locations. In June, 1878 their Annual Convention was held in Boston. The next visit was in June, 1895 to Hotel Pemberton in Boston Harbor (Hull, Mass.)[54] A.S.C.E. conventions were held at Bretton Woods, N. H. in 1909 and at Portsmouth, N. H. in 1922. Fall meetings were held in Boston in 1929 and 1937. The Society is honored that the American Society has chosen Boston as the scene of its Fall Meeting in October, 1948, in recognition of our Centennial Year! Each year a Student Night and other joint meetings are held by the Society and the Northeastern Section, A.S.C.E.

Other national societies have held meetings in Boston in which our Society has been privileged to take part. Among these are included a visit by the Canadian Society of Civil Engineers in 1900 at which time a joint meeting was held with our Society. In 1894, members of the Société des Ingénieurs Civils de France visited Boston.[55] Our Society subscribed $550 toward the cost of maintaining a headquarters for engineers attending the Columbian Exposition (World's Fair) at Chicago in 1893.[56] Cooperative relations have been maintained with the New England Waterworks Association which jointly occupied quarters with our Society at Tremont Temple for many years. Joint outings were held in June for a number of years and a program of sports and entertainment carried out.

Committee Activities

Historically, the Committee on Library deserves first mention. It has been included in every list of committees since 1848.[57] The

[53]The E.S.N.E. now includes 18 organizations with a net membership of about 6000.

[54]The printed program included an 80-page section, which featured the water, sewerage, transit and park systems of Metropolitan Boston.

[55]After returning to France they sent medals and souvenirs to be given to our members who had entertained them.

[56]This sum was obtained through contributions from B.S.C.E. members.

[57]At least 25 members have served as Librarian since the Society was organized.

complete history of the library may be traced through their reports. Throughout much of the Society's life there have been committees on Meetings, Program, Censorship of Papers, Publication, etc.; their duties are obvious from the titles. For about 30 years (1885 to 1915), the Committee on Excursions was one of the most active in the Society (see p. 379).

Separate committees are appointed each year for the Desmond FitzGerald and Clemens Herschel Awards and for each Section Prize. A standing committee is in charge of the John R. Freeman Fund. For the past 35 years the Hospitality (formerly Social Activities) Committee has been responsible for the dinners before the meetings and for excursions and outings.

A Welfare Committee has been active in connection with employment, particularly during the depression of the 30's, and on matters concerned with compensation and other aspects of the welfare of the membership (see p. 396). A Committee on Relations of Sections to the Main Society has served an important function in coordination of programs and similar matters.

Committees on Membership and Publicity have been appointed from time to time when the need arose. Attention has been called to numerous studies which have been made in connection with permanent quarters; these have been carried out by Committees on Quarters appointed at various times.

The foregoing committees have dealt principally with the internal affairs of the society and with matters directly concerning the welfare of its members. Other committees have been appointed on specific problems of the engineering profession and on public affairs. Although the list of these is too long to enumerate, attention is called to a few. In 1875, committees were appointed on the Introduction of the Metric System and on Preservation of Timber. The latter committee does not appear to have been active but the one on the Metric System made comprehensive reports for many years. The first paper presented before the reorganized Society in 1874 was on that subject. Other committees have been appointed on such subjects as Preservation of National Parks, National Department of Public Works, Highway Bridges, Weights and Measures, New State Map, Research, Legislation, Classification of Engineers in Civil Service, Licensing of Engineers and Building Codes. At present the roster of committees of this character includes Building Laws and Building Construction, and Competitive Bidding for Engineering Services. Since the formation of the Engineering Societies of New England in 1922 to coordinate the activities of the affiliated groups, it has been customary for that organization to name committees for the consideration of some of the broader subjects affecting the engineering profession. Many B.S.C.E. members have served on these E.S.N.E. committees.

The Society in recent years has appointed several committees to study specific problems of importance both to the civil engineer and to the community. The results accomplished by these committees have been of such outstanding value that they are presented in some detail.

Boston Subsoils. In 1914, *J. R. Worcester* published in the first issue of the B.S.C.E. Journal a treatise on "Boston Foundations," which recorded many borings. For several years thereafter no boring records were collected but in 1921 a Committee on Boston Subsoils was appointed to carry on this work. Between 1923 and 1931, the Committee collected about 3900 boring records. The final report of the Committee, published in the September, 1931 Journal, contains a complete tabulation of the boring records in Boston and Cambridge together with nine detached maps showing the location of borings, geological cross-sections and a contour map.[58] Copies of these maps and index cards showing data of the individual borings were placed in the rooms of the Society. This information is available to engineers, architects and builders. Probably in no other city in the country is there such a comprehensive record of boring data assembled for convenient use. In 1943, another Committee on Boston Subsoils was appointed to continue the collection of boring data along the lines of the 1931 report and to consider the possible collection of water table data, settlement records and other information. This work is now in progress.

Rainfall and Run-off of New England. In 1916, a Committee on Run-Off was appointed "to collect, compile, analyze and report upon the best figures of run-off in New England, which are available for water power purposes." After a five-year study, the Committee presented its report, which was published in the October, 1922 Journal. Owing to the expense involved, the published report did not contain the duration tables and complete records for twelve stations, but these were made available at the Society's rooms. Data were later collected in the name of the Committee for the period from 1922 to 1937. The final assembly of this information was made by the chairman, *Arthur*

[58]Harry E. Sawtell served as chairman of the Committee on Boston Subsoils.

T. Safford, and was presented as a contribution by him to the Society. This paper "Rainfall and Run-Off of New England," a comprehensive treatise of 100 pages, was published as Section 2 of the April, 1939, Journal.

Flood Committee Reports. New England was the scene of floods in 1927, 1936 and 1938. Immediately after the November, 1927 flood, a committee was appointed to collect and analyze all possible information concerning it. The Committee presented a very complete report, published in the September, 1930 Journal. This report included: an analysis of the 1927 flood together with data on earlier floods; a study of flood factors and characteristics of New England rivers; a new "flood formula" recommended for New England; analysis of flood prevention measures; and a study of costs and economic phases. The value of the "flood formula" and methods recommended have been recognized nationally.

Immediately after the 1936 flood, another committee was appointed. While this study was in progress, New England was hit by the "hurricane flood" of 1938 and it was decided to extend the work of the Committee to cover this flood also. The final report of this 2nd Flood Committee was published as Section 2 of the January, 1942 Journal. This report assembled in one volume information on New England storm rainfalls and floods; a summary of the progress of engineering studies of all factors relative to rainfall, run-off, flood routing, flood frequency; a summary of what had been done and was proposed for the prevention and control of floods in New England; and a description of methods for flood warnings and handling of flood emergencies in force in New England. *Arthur T. Safford,* chairman of the 1927 Flood Committee, served from 1936-37 as chairman of the 1936 Committee; *Howard M. Turner* was chairman from 1937-41. In addition to members of the Society, the 1936 Flood Committee included a number of engineers throughout New England. Through the notable reports on Rainfall and Run-off and on the New England Floods, the Society has made contributions of inestimable value to New England.

Sanitary Section Committees. Attention has been called to the reports of several important committees appointed by the Sanitary Section, which have been published in the Journal (see p. 380).

Public Affairs

The Society, directly and through its members, has always been active in those public affairs in which the civil engineer could be of service. Much of this has been done through the reports of special committees previously mentioned. Recommendations of these committees have resulted in formal votes of the Society, by letter ballot, urging approval or disapproval of pending legislation. Many matters have been referred to the Society or to the Board by governmental authorities; these include requests for the recommendation of civil engineers qualified to serve on public boards in connection with such matters as Zoning, Licensing of Engineers, Civil Service Examiners, etc.

For several years the Society was a member of the Federated American Engineering Societies and of American Engineering Council. However, where matters are of a national character, the Society has often taken the position that action by the national engineering societies is more appropriate than by a local society. Since the formation of the Engineering Societies of New England, action on public affairs is usually taken by that group—it appearing more logical for the Society to lend its whole-hearted support to that more inclusive organization than to act individually.

Miscellaneous Activities

Society Badge. In 1903, a committee was appointed to consider the adoption of an official badge. Five designs were prepared, one of which embodied the target of the early Boston Leveling Rod.[59] After considerable discussion, the Society adopted the present badge, a shield bearing 1848 and Boston Society of Civil Engineers in gold letters on a maroon background.

Code of Ethics. The Society adopted its present Code of Ethics on December 18, 1912.[60] It was probably the earliest Code of Ethics to be adopted by an engineering society. The Engineers' Council for Professional Development (E.C.P.D.) has recently prepared a Canon of Ethics which it has recommended to the engineering societies throughout the country.

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[59] The "Boston" rod was made by W. M. Pool, Easton, Mass. It was apparently designed by Charles Harris in the Boston City Surveyor's Office in the 1850's. It was used by the city of Boston and by other surveyors for many years. It had a fixed target; there were no numbers on the face, the readings being obtained from Verniers on the side.

[60] Printed in Monthly Bulletin, B.S.C.E., November, 1912; also in the Jour., Assoc. of Eng. Soc., vol. L, p. 4.

World Wars. During both World Wars the Society remitted the dues of members in the Armed Forces who were unable to participate in the Society's activities. In 1917, the First Corps of Cadets of Boston, in continuous existence since 1741, raised an engineer regiment for the National Guard (101st Regiment, U. S. Engineers). The Society voted its support and assistance to this activity and obtained subscriptions amounting to over $2200 for a fund to be used for the benefit of the regiment. It was used to equip a band—the 101st becoming the first engineer regiment to have its own band attached.

Employment. As early as 1889, the Secretary was directed to maintain a list of members seeking employment. In 1910, the Board established an Employment Bureau. Lists of men available and positions open were maintained at the Society rooms. Brief notices as to men available were published each month in the Bulletin until 1913 and thereafter in the Journal. The Society's employment service continued until the formation of the Affiliated Technical Societies of Boston in 1922, after which a similar service was maintained by that organization for all the member groups. In 1932 during the early days of the depression the Engineering Societies of New England and the Boston Society of Architects organized the Emergency Planning and Research Bureau, Inc., which rendered valuable employment service. This organization continues to operate an employment service for engineers and architects. The Society has cooperated in this work through its Welfare Committee.

One Hundred Years—1848-1948

In these "high lights" of the *first* 100 years of our Society, many items have been omitted because they were deemed of lesser importance --and some no doubt may have been overlooked. In concluding this Centennial History of the Boston Society of Civil Engineers, *oldest engineering society in America,* there seem no words more fitting than those of *Desmond FitzGerald,* fifty years ago, in his Semi-Centennial Address.[61]

"In what has already been said, I have attempted to give an historical account of the formation and progress of this Society during the past fifty (*one hundred*) years. Such a narrative must necessarily deal with facts which can be of little interest outside of our own membership, and with statistics which, I am afraid, tax even your patience. I trust, however, they

[61]Jour., Assoc. of Eng. Soc., vol. XXI, p. 263.

may at least be useful in bringing to your minds the paths, more or less familiar, which we together have been following at different times in this eventful half-century (*century*),—paths at times clouded by the passing storm, and perhaps even at times by failure, but more often illumined with the bright rays of success and of progress.

"In the laborious and responsible work of the profession there is little time for looking backward; the swimmer who turns his eyes from the goal is cast into the eddy; but there are times when retrospection is profitable, and a glance into the past, at least once or twice in a century, is instructive and at least pardonable.

"As we consider the record of this Society, founded by the early toil and constant struggles of the fathers of the profession, built solidly on the eternal principles of truth and honesty, and rising slowly but surely out of every discouragement to its present commanding proportions, we have reason to be proud,—proud of our Society, and proud of the achievements of our members in every branch or specialty of the work of the civil engineer, who, by patience, by industry, by ability, and, best of all, by unswerving integrity, have aided in lifting the noble profession of engineering to its place among the great professions of the world".

PAST AND PRESENT OFFICERS OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

And Years in which They Held Office

The figures for year during which office was held are printed without those of the century, except for 1948. Unless shown otherwise by footnote, office was held from March of year given to the following March. Names of Deceased Members are printed in italics.

Key to Memoirs:—B, Jour., B.S.C.E.; A, Trans., A.S.C.E. (volume and page).

Name	President	Vice-President	Secretary	Treasurer	Director	Memoir
Adams, Henry S.	—	—	—	—	25—26	B15—442
Allen, C. Frank	99	97—98	—	—	—	—
Allen, Charles M.	26	22—23	—	—	14—15	—
Alvord, Henry B.	—	—	—	—	[1]39	A105—1794
Ashburner, Samuel	—	—	—	—	50—51	B23—182
Babcock, John B., 3d	35	32—33	22—28	—	30—31	—
Baldwin, James F.	[2]48—49	—	—	—	—	B23—183
Barbour, Frank A.	20	—	—	—	10—11	B34—335
Barnes, T. Howard	—	99—00	—	—	—	B15—101
Barrows, Harold K.	36	33—34	—	—	30—31	—
Bennett, Joseph	—	—	—	—	[3]48—51	B23—186
Bidwell, Lawson B.	01	—	—	—	—	B10—318
Blake, Edmund M.	—	—	—	—	15—16	B8—287
Blake, John H.	—	—	[4]48	—	—	B23—187
Borden, Simeon	[5]52—56	[6]50—52	—	—	—	B23—188
Bowers, George	—	—	—	—	08—09	B18—64
Brackett, Dexter	97	95—96	—	—	—	B2—351
Breed, Charles B.	28	25—26	—	—	13—14	—
Brooks, Frederick	04	02—03	—	—	90—93	B6—178
Brown, William M.	—	—	—	—	01—02	B7—68
Bryant, Henry F.	10	08—09	—	—	—	—
Burden, Harry P.	[7]44	[8]44	—	—	33—34	—
Burton, Alfred E.	—	—	—	—	99—00	—
Cameron, Edward H.	—	—	—	—	28—29	—
Camp, Thomas R.	—	—	—	—	40—41	—
Carson, Howard A.	98	—	—	—	—	A96—1386
Carter, Henry H.	—	94—95	—	—	—	A100—1624
Carty, John E.	—	—	—	—	20—21	—
Casagrande, Arthur	—	—	—	—	36—37	—
Chaplin, Winfield S.	—	—	—	—	[9]90	—
Cheney, Herbert N.	—	—	—	—	22—23	B20—14
Chesbrough, Ellis S.	—	[10]52	—	[11]53—55	[3]48—51	B23—191
Clair, Miles N.	—	—	—	—	45—46	—
Clapp, Otis F.	—	04—05	—	—	—	B5—139
Cobb, Edwin B.	—	—	47	—	—	
Coburn, Charles L.	—	—	—	[12]41—42	—	—
Coburn, Raymond W.	—	35—36 45	—	—	26—27	
Coffin, Freeman C.	—	[13]05—06	—	—	—	A58—532
Coffin, George W.	—	—	—	—	47—1948	—
Crandall, J. Stuart	—	—	—	—	35—36	—
Curtis, Ralph E.	—	15—16	—	—	—	—
Darracott, Franklin	—	—	—	[14]74	—	B23—195
Davis, Joseph P.	[15]80	77—79	—	—	—	B4—437

[1]Mar. 15, 1939—April 20, 1939.
[2]July 3, 1848—Mar. 25, 1850.
[3]July 3, 1848—Mar. 22, 1852.
[4]July 3, 1848—Mar. 6, 1849.
[5]Dec. 6. 1852—Oct. 28. 1856.
[6]Mar. 25, 1850—Dec. 6, 1852.
[7]Aug. 13, 1944—Mar. 21, 1945.
[8]Mar. 22, 1944—Aug. 13, 1944.
[9]Feb. 19, 1890—Mar. 18, 1891.
[10]Dec. 6, 1852—Mar. 1, 1853.
[11]Mar. 1. 1853—Oct. 1, 1855.
[12]Mar. 19, 1941—Dec. 17, 1942.
[13]Mar. 15, 1905—Nov. 11. 1906.
[14]June 8, 1874—Aug. 7, 1874.
[15]Mar. 17, 1880—Sept. 15. 1880.

PAST AND PRESENT OFFICERS—*Continued*

NAME	President	Vice-President	Secretary	Treasurer	Director	Memoir
DEAN, ARTHUR W.	33	31—32	—	—	16—17	—
Dean, Francis W.	—	07—08	—	—	—	—
Dearborn, William L.	—	—	—	—	51	B23—195
Dexter, George M.	[3]50—52	[2]48—49	—	—	—	B23—196
Doane, Thomas	[16]74—79 [17]80—83	—	—	—	—	A39—690
DORE, STANLEY M.	—	—	—	—	42—43	—
Dorr, Edgar S.	—	—	—	—	21—22	—
DRESSER, HERMAN G.	—	—	—	1948	42—43	—
Eaton, Arthur C.	—	—	—	—	[18]33	A99—1445
Eaton, Horace L.	—	—	[19]82—87	—	—	A36—554
Eddy, Harrison P.	14	—	—	—	—	A104—1867
EDDY, HARRISON P., JR.	—	1948	—	—	27—28	—
EDWARDS, ATHOLE B.	[20]42	[21]41—42	—	—	36—37	—
Ellis, John W.	05	—	—	—	—	B5—360
Ellsworth Samuel M.	[22]44	43	—	—	40—41	B32—102
FAIR, GORDON M.	39	37—38	—	—	31—32	—
Farnham, Irving T.	—	—	—	—	[23]07—08	A81—415
FARWELL, CARROLL A.	45	44	—	—	37—38	—
Fay, Frederic H.	13	11—12	—	—	[24]08—10	A72—1691
Felton, Samuel M.	—	—	—	—	49—50	B23—199
FERGUSON, JOHN N.	—	—	—	—	13—14	—
Fernald, Clarence T.	—	—	—	—	17—18	B14—150
FitzGerald, Desmond	88—89	[25]74—76	—	—	—	B14—427
FLOOD, FRANK L.	—	—	—	—	46—47	—
Francis, George B.	09	—	—	—	02—03	B2—125
Francis, James B.	[26]74	—	—	—	—	B23—200
Freeman, John R.	93	89—91	—	—	—	A98—1471
French, Alexis H.	00	98—99	—	—	—	B2—327
GIBBS, FREDERICK S.	—	—	—	—	1948	—
GINDER, CHESTER J.	—	—	—	[27]42—47	1948	—
Goodnough, X. Henry	—	01—02	—	—	98—99	A101—1565
GOW, CHARLES R.	15	13—14	—	—	11—12	—
GRAMSTORFF, EMIL A.	—	—	—	—	43—44	—
GUNBY, FRANK M.	23	20—21	—	—	—	—
HAERTLEIN, ALBERT	41	40	—	—	35—36	—
Hale, Richard A.	16	14—15	—	—	95—96	B17—139
HALE, RICHARD K.	25	23—24	—	—	21—22	—
Hastings, Lewis M.	—	16—17	—	—	—	—
Herschel, Clemens	90	—	—	[28]74—79	—	B19—313
Hodgdon, Frank W.	06	00—01	—	—	96—97	B11—187
Hollis, Ira N.	03	—	—	—	00—01	—
HOLMGREN, RICHARD S.	—	—	—	—	[29]39—40	—
HORNE, RALPH W.	32	30—31	—	—	28—29	—
HOWARD, JOHN L.	—	—	—	—	18—19	—
Howe, Edward W.	07	—	—	92—05	—	B19—362
HUTCHINS, EVERETT N.	—	47—1948	29—46	—	—	—
JACKSON, DUGALD C.	22	—	—	—	—	—
Johnson, William S.	—	12—13	—	06—09	—	—
JOY, C. FREDERICK, JR.	—	—	—	—	41—42	—
KENNISON, KARL R.	38	36—37	—	31—35	—	—
Kent, S. Stanley	—	[30]43	—	—	38—39	B30—212
Kimball, George A.	02	—	—	—	—	A87—1368
KINGSBURY, FRANCIS H.	—	—	—	—	45—46	—
KINNISON, HARVEY B.	47	45—46	—	—	39—40	—
KLEINERT, ALBERT E.	—	—	—	—	44—45	—
Laurie, James	—	—	—	—	[31]48—49	B23—210
Main, Charles R.	[32]42	41	—	36—40	24—25	B29—286
Main, Charles T.	11	09—10	—	—	06—07	B30—128
Manley, Henry	92	—	—	80—91	93—94	B7—223

[16]Aug. 7, 1874—Mar. 17, 1880.
[17]Oct. 20, 1880—Mar. 19, 1884.
[18]Mar. 15, 1933—Mar. 6, 1934.
[19]Dec. 20, 1882—May 18, 1887.
[20]Oct. 21, 1942—Mar. 17, 1943.
[21]Mar. 19, 1941—Oct. 21, 1942.
[22]Mar. 22, 1944—Aug. 13, 1944.
[23]Mar. 20, 1907—Sept. 19, 1908.
[24]Nov. 18, 1908—Mar. 15, 1911.
[25]Sept. 4, 1874—Mar. 21, 1877.
[26]Apr. 27, 1874—Aug. 7, 1874.
[27]Jan. 14, 1942—Mar. 31, 1948.
[28]Sept. 4, 1874—Mar. 17, 1880.
[29]Oct. 20, 1939—Mar. 19, 1941.
[30]Mar. 17, 1943—May 16, 1943.
[31]July 3, 1848—Mar. 5, 1850.
[32]Mar. 18, 1942—Aug. 22, 1942.

PAST AND PRESENT OFFICERS—*Continued*

NAME	President	Vice-President	Secretary	Treasurer	Director	Memoir
MARSTON, FRANK A.	27	24—25	—	—	22—23	—
McClintock, William E.	94	[33]90—92	—	—	—	B18—121
Metcalf, Leonard	19	06—07	—	—	04—05	B14—148
Miller, Edward F.	—	—	—	—	05—06	—
MOHR, HENRY A.	—	—	—	—	44—45	—
MOIR, ROBERT W.	—	—	1948	—	—	—
MOORE, LEWIS E.	30	27—28	—	—	17—18	—
MOSES, JOHN C.	—	—	—	—	32—33	—
Nott, Samuel	—	—	[34]49—74	—	[4]48	B23—212
Noyes, Albert F.	95	92—93	—	—	—	A36—560
Parrott, William P.	—	[35]53—67	—	[36]48—52	—	B23—214
Philbrick, Edward S.	—	80—83	—	—	—	A38—454
PIKE, WALDO F.	—	—	—	—	[37]41	—
Porter, Dwight	—	03—04	—	—	97—98	A102—1639
PROTZE, HERMAN G.	—	—	—	—	47—1948	—
Rice, George S.	—	—	[38]74—80	—	—	A85—1713
Rice, L. Frederick	87	84—86	—	—	—	B6—313
Rogers, Edwin H.	24	21—22	—	—	18—19	—
Rollins, James W.	12	10—11	—	—	—	A101—1631
ROPES, LAWRENCE G.	—	—	—	—	[39]41—42	—
SAFFORD, ARTHUR T.	34	28—29	—	—	23—24	—
SAMPSON, GEORGE A.	46	—	—	—	25—26	—
Sawtell, Harry E.	31	29—30	—	—	26—27	B26—148
SHAW, ARTHUR L.	[40]40	[41]39—40	—	—	29—30	—
Shepherd, Frank C.	—	—	—	—	27—28	—
SHERMAN, CHARLES W.	—	17—18	—	10—14	—	—
Snow, J. Parker	—	—	—	—	[42]10—11	A101—1650
SPOFFORD, CHARLES M.	18	—	—	—	12—13	—
Stearns, Frederic P.	91	87—88	—	—	—	A83—2132
STREET, L. LEE	—	—	—	—	[43]10—12	—
Swain, George F.	96	93—94	—	—	91—92	B19—364
TAYLOR, DONALD W.	—	—	—	—	46—47	—
THOMPSON, SANFORD E.	—	—	—	—	16—17	—
Thorndike, Sturgis H.	—	—	—	—	19—20	B15—481
Tinkham, S. Everett	—	—	[44]80—82 [45]87—21	—	—	B8—291
TURNER, HOWARD M.	43	42	—	—	37—38	—
Tuttle, Arthur S.	—	—	—	—	19—20	—
Varney, Henry A.	—	—	—	—	29—30	A71—1539
Vose, George L.	84—86	—	—	—	—	—
Waldron, Samuel P.	—	—	—	—	34—35	—
Walker, Frank B.	[40]40	38—39	—	—	34—35	—
Wason, Leonard C.	—	18—19	—	—	14—15	A103—1908
WEAVER, FREDERIC N.	1948	46—47	—	—	38—39	—
WESTON, ARTHUR D.	37	34—35	—	—	31—32	—
Weston, Robert S.	21	19—20	—	—	12—13	B31—40
Whipple, George C.	17	—	—	—	15—16	B13—131
Whitney, Frank O.	—	—	—	15—30	94—95	A102—1667
Whitwell, Willliam S.	—	—	—	—	[3]48—51	B23—221
WILBUR, JOHN B.	—	—	—	—	43—44	—
Winsor, Frank E.	29	26—27	—	—	24—25	A105—1957
WOOD, DANA, M.	—	—	—	—	23—24	—
Wood, Henry B.	—	—	—	—	20—21	B14—151
Woods, Henry D.	—	96—97	—	—	—	B19—361
Worcester, Joseph R.	08	—	—	—	03—04	B30—214
WRIGHT, EDWARD	—	—	—	—	32—33	—

[33]Feb. 19, 1890—Mar. 15, 1893.
[34]Mar. 6, 1849—Aug. 7, 1874.
[35]Mar. 1, 1853—Mar. 4, 1868.
[36]July 3, 1848—Mar. 1, 1853.
[37]Mar. 19, 1941—May 2, 1941.
[38]Aug. 7, 1874—Apr. 21, 1880.
[39]Sept. 24, 1941—Mar. 17, 1943.
[40]Sept. 18, 1940—Mar. 19, 1941.
[41]Mar. 15, 1939—Sept. 18, 1940.
[42]Sept. 21, 1910—Mar. 20, 1912.
[43]Sept. 21, 1910—Mar. 19, 1913.
[44]Apr. 21, 1880—Dec. 20, 1882.
[45]May 18, 1887—Apr. 21, 1921.
[46]Mar. 20, 1940—June 3, 1940.

COMMITTEES

1948-1949

NOMINATING COMMITTEE

Past Presidents (Members of the Committee)

Athole B. Edwards
Howard M. Turner
Harry P. Burden

Dean Peabody, Jr.
William P. Hyland
Walter E. Merrill
(Term expires March, 1949)

George F. Brousseau
Frank L. Cheney
William E. Stanley
(Term expires March, 1950)

SPECIAL COMMITTEES

Program

Frederic N. Weaver, *Chairman, ex-officio*
Thomas R. Camp
William E. Stanley
Stanley M. Dore
Robert W. Moir
Charles M. Anderson
Allen J. Burdoin
Oliver G. Julian
R. Newton Mayall
John G. W. Thomas

Publication

Charles E. Knox, *Chairman*
John B. Babcock
Edwin B. Cobb
Leonard J. A. Fenocketti

Library

Robert W. Moir, *Chairman*
James F. Brittain
Elliot F. Childs
Edwin B. Cobb
George W. Hankinson
Thomas C. Coleman, *ex-officio*
Ralph M. Soule
Henry I. Wyner

Hospitality

Edward S. Averill, *Chairman*
Joseph C. Lawler
Charles T. Main, 2nd
James C. M. Tillinghast

Relations of Sections to Main Society

Oliver G. Julian, *Chairman*
Charles M. Anderson
Allen J. Burdoin
William J. Downey, Jr.
R. Newton Mayall
John G. W. Thomas

John R. Freeman Fund

Howard M. Turner, *Chairman*
Charles M. Allen
William F. Uhl

Desmond FitzGerald Award

Byron O. McCoy, *Chariman*
John B. Wilbur
Jack E. McKee

Sanitary Section Award

Jack E. McKee, *Chairman*
Harry P. Burden
George F. Brousseau

Structural Section Award

John B. Wilbur, *Chairman*
Henry Brask
Howard A. Gray

Transportation Section Award

Alexander J. Bone, *Chairman*
Francis T. McAvoy
Ernest L. Spencer

Hydraulics Section Award

Byron O. McCoy, *Chairman*
Elliot F. Childs
Harold K. Barrows

Surveying and Mapping Section Award

Charles O. Baird, *Chairman*
Alexander J. Bone
Chester A. Moore

Subsoils of Boston

Donald W. Taylor, *Chairman*
Miles N. Clair
Irving B. Crosby
Stanley M. Dore
Lawrence G. Ropes

Investment Committee

Herman G. Dresser, *Chairman*
Frederic N. Weaver
Everett N. Hutchins

Auditing Committee

George W. Coffin
Chester J. Ginder

Membership Central Committee

Frank L. Lincoln, *Chairman*
George F. Brousseau
Chester A. Moore
Francis H. Kingsbury
James F. Brittain
Robert W. Moir, *ex-officio*

Quarters Committee

Howard M. Turner, *Chairman*
Herman G. Dresser
Albert Haertlein
E. Sherman Chase
John B. Wilbur
Robert W. Moir, *ex-officio*

Building Laws and Building Construction

John R. Nichols, *Chairman*
Emil A. Gramstorff
Burtis S. Brown
Arthur L. Shaw
Thomas Worcester

Publicity Committee

Stephen Haseltine, Jr., *Chairman*
Jack E. McKee
Ernest L. Spencer
Llewellyn T. Schofield
James C. M. Tillinghast
Gardner K. Wood

Safety Committee

Herman G. Protze, *Chairman*
John R. Nichols
Henry I. Wyner

Insurance Committee

Frank L. Flood, *Chairman*
Donald W. Taylor
George A. Sampson

Competitive Bidding for Engineering Services

Ralph W. Horné, *Chairman*
John P. Wentworth
George W. Coffin
George G. Bogren
Herman G. Dresser

Changes in By-Laws

Frederic N. Weaver, *Chairman*
Thomas R. Camp
Carroll A. Farwell