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TESTS OF CENTRIFUGAL PUMPS

The pumping of water for irrigation purposes, from both underground and surface sources, is destined to become of great economic importance in the not far distant future, especially in the western portions of North America. In certain sections, providing a water supply were available, lands now rated as of low productive properties could be transformed into profitable and highly productive localities, so that when a water supply is available, there is probably no better investment for a man with a small ready capital, than the building of a pumping plant with a capacity sufficient to irrigate from 20 to 40 acres of land where the depth of water does not exceed 50 feet. Such land is obtainable at low prices on the mesas bordering the river valleys and is particularly desirable where orchard fruits and garden produce are raised with success, where for such products there is a well established market and where finally, land irrigated by gravity irrigation systems can only be obtained upon payment of prices beyond the means of the average investor. In many localities of our West such conditions already exist to some extent and it is in such localities as well as in the more promising "dry-farming" districts that the development of the independent pumping plant is most likely to occur. The central station electrical pumping plant system is a phase of the matter requiring the most careful study of economic and engineering features by experts and will not be touched upon here. The private project should, however, not be entered upon by the person who does not possess some little experience in irrigation affairs so far as they relate to irrigation pumping at least. The fixed charges and operating expenses of a pumping plant are so high under usual conditions that only by the most careful attention to details of equipment and by the exercise of good management in the operation of the pumping plant as well as farm will the enterprise be made to pay or be found as profitable as the preliminary estimates might lead one to expect. In a recent bulletin of the New Mexico Experiment Station, Mr. B. P. Fleming and J. B. Stoneking give results of tests on a number of pumps, and their conclusions as taken up in this article are interesting.

In the matter of equipment it can scarcely be supposed that the person without special training will make a wise selection particularly as to the size and type of pump and motive power. As a matter of fact most pumping plants are put in under contract with some firm supplying or dealing in machinery and the owner beyond the most general specifications is given, and probably deserves, but little opportunity to decide the character of machinery which is put into his plant. Moreover after the plant is put into operation the owner usually takes it for granted that the amount of water guaranteed by the contractor has been obtained and rarely undertakes to determine if the facts support this assumption. In many instances tests have shown centrifugal pumps to be below specifications and guaranteed capacity. This condition of affairs is often a source of annoyance to contractors. This article is written with a view of enabling a prospective purchaser to form a definite idea of the capacity and other essential points from a source other than the manufacturer's pamphlet. The details given below will aid one in selecting a pump and will also give some information regarding the speed at which the pump must be operated to secure a given discharge at a given head. The engine horsepower may then be determined from the curve and the proper size of driving pulley ascertained when the diameter of the pump pulley is known.

These pump discrepancies at times assume large proportions, as may be seen from a glance at Tables No. 1 and No. 2, which are the results of recent investigations at the New Mexico Experiment Station.

Without exception these plants had been designed to secure the rated discharge and the pumps selected were those which according to manufacturers' catalogs would give these quantities, the engine power being based on figures secured from the same source. The method of testing these devices were carried out under careful supervision.

The suction and discharge heads were measured by mercury gauges, and the higher discharge heads by an accurate pressure gauge of the Bourdon type. The suction and dis-

Table 1.

Pump Serial No.	Size of Pump	Range of speed through which operated		Greatest discharge at		Corresponding total heads for greatest discharges		Highest Efficiency attained at any speed	Maker's Rating or "Economic Capacity"	Conditions at highest efficiency attained		
		Lowest	Highest	Lowest Speed	Highest Speed	Lowest Speed	Highest Speed			Discharge Gallons per Min.	Head Ft.	Speed R. P. M.
	Inches.	R.P.M.	R.P.M.	G.P.M.	G.P.M.	Ft.	Ft.	%	G.P.M.			
1	2½	590	1245	200	500	16	55	48	185	250	48	920
2	2	700	1415	135	200	22	100	55	95–125	115	40	860
3	4	675	1320	265	550	14	50	51	400	400	72	1320
4	6	320	370	1040	900	16	23	35	1200–1800	750	19	320
5	1½	940	2130	62	135	13	60	39	55–75	60	13	940
6	6	290	455	600	860	11	32	42	1050	590	11	290
7	6	560	855	510	600	16	35	33	880	600	35	855
8	6	570	750	880	760	17	52	56.5	1100	500	34	570
9	6	700	900	720	800	22	43	48	800	800	42	900
10	4	760	1235	450	600	14	45	56	400	350	44	960
11	4	300	550	300	550	11	17.5	50	450	250	24	400

charge pitometer tubes were in each case tapped into their respective pipes as close to the suction and discharge flanges of the pump as possible, and care was taken to see that the inner tips of the tubes did not project beyond the inner surfaces of the pipes. In determining total head, correction was always made for the vertical distance between the center of the pressure gauge and the point at which the suction gauge was tapped into the suction pipe. Where a mercury manometer was used on the pressure side, correction was made for the water column in the manometer. The variation of head was obtained by the use of a gate valve in the discharge line of the pump, the throttling effect giving the equivalent of increased head. The speed of the pump was measured by a Schaeffer and Budenberg Tachometer belted directly to the shaft of the pump. The power for driving the pumps was a three phase induction motor located on a track on the surface near the edge of the pit, so that the drive was in all cases directly from the motor to pump without the use of a jack shaft. The power input to the pump was determined by the use of two Western Electric single phase indicating wattmeters and multipliers connected in the usual way. The power output of the motor was determined by putting a friction brake on the motor pulley and determining for different brake loads the indicated wattage from which a curve was drawn with indicated wattage as one ordinate and brake horse power of motor as the other thus enabling a knowledge of the power being delivered by the motor to be obtained immediately from the readings of the wattmeters. There was thus provided a most efficient and accurate means of measuring the power input to the pump, the loss by belt transmission being regarded as negligible and because of the construction of the pumps entirely unavoidable. The measurement of the pump discharge was based upon the flow over a standard trapezoidal weir cut in a sheet of No. 16 galvanized iron. The weir notch was located at the front end of the galvanized iron tank into which the water was discharged by the pump through a flume leading to the rear end. A series of baffles erected vertically and a number of large pieces of wood floating behind the baffles and first receiving the impact of the water discharged into the tank were found ample to reduce the disturbance back of the weir so that the depths on the crest of the same could be determined by a hook gauge. Such precautions insured the determination of flow to well within the recognized limits of accuracy of weir measurements, in other words the flow of water was determined to within probably 2 per cent. or at the outside 3 per cent. of accuracy. The water after passing over the weir was discharged directly into the suction tank, so that no variation of level in the suction tank could occur and the only variation of suction head was that resulting from the increased friction head as the discharge of the pump increased.

Table 2.

Plant No.	Size and Type of Pump.	Rated Capacity. G.P.M.	Actual Measured Maximum Capacity G.P.M.
1	5 inch—vertical two stage.......	700	350
2	6 inch—horizontal single stage..	1000	800
3	3 inch—horizontal single stage..	225	250
4	5 inch—horizontal single stage..	700	272
5	5 inch—vertical single stage.....	1000	830
6	4 inch—vertical single stage.....	400	325

After being overhauled, cleaned and packed, each pump was mounted securely upon timbers spanning the suction tank, and suction and discharge piping of size suited to the pump was attached. Suction and discharge pressure gauges were tapped in as before described. The tachometer was belted directly to the pump shaft by pulleys giving proper speed ratios. Using a belt of constant length and shifting motor on its track, different sized pulleys were placed in succession on the motor shaft and pump shaft so that the pump could be run at several constant speeds, the motor speed being constant and invariable except, of course, with the slight changes in frequency. For each speed the gate valve in the discharge pipe was first opened wide, thus giving the lowest total head and maximum discharge obtainable, after which the valve was closed tight to secure the head which the pump could maintain without discharge. Between these two limits several runs were made in each case to give the various discharge heads by different openings of the gate valve. Upon the completion of such a series the pump speed was changed by changing the motor pulley and the foregoing repeated. Previous to and after each run at a given speed the power was measured which was required to drive the pump empty or without priming. This was designated as mechanical friction loss or the power lost in the pump bearings and in windage.

Each pump was operated under identically similar conditions and all measurements were made with the same apparatus. The results should, therefore, it would seem, give a reasonably accurate idea not only of the absolute but also of the comparative merits of the different makes and types of pumps tested.

The conclusions reached may be stated as:—

(1) The capacity of a centrifugal pump is a variable, depending upon the speed at which it is run and the total head against which it operates. Conversely, every centrifugal pump when run at a certain speed will give a certain discharge at a certain head. If the speed be increased with the head constant, the discharge will be increased according to a definite law, and if the speed be constant and the head decreased, the discharge will generally increase. But every pump has certain conditions under which it works best, as shown in the following conclusion:

(2) Every centrifugal pump has a definite head for different speeds at which it operates most economically from the standpoint of fuel cost, and in order to force the water to this head this speed should be used if, as is frequently the case, the cost of power is the most important factor in the total cost of operation.

(3) The ratings of centrifugal pumps as given in the manufacturers' catalogs or circulars are incomplete and often misleading in the determination of the proper size of a centrifugal pump for a given lift and capacity. In some cases the rating is apparently based on the maximum quantity of water the pump will discharge which may be at a very high speed and low head. Very frequently the rating is given in terms of "economic capacity," which is probably a term of doubtful meaning. Instead of rating pumps by the so-called "economic capacity," it would greatly add to the advantage of the prospective purchaser if the manufacturer should publish tables or exhibit curves based on reliable tests from which one might choose the size of pump and determine the speed which would give the greatest economy or highest efficiency for the desired discharge at the given head.

(4) Centrifugal pumps of the types and sizes used in small irrigation pumping plants are machines of markedly low efficiency as usually operated, and in figuring on the power requirement with ordinary stock pumps, one must expect that from one-half to two-thirds of the power of the engine or motor will be wasted in water friction and churning effects within the pump and in mechanical friction in its bearings and stuffing boxes.

(5) Large pumps show better efficiencies than small ones, hence it may be better to use a pump of over rather than under size, other conditions being the same.

(6) The outlet angles of the impellers of small pumps probably have not as much effect on their efficiency as have the shape of the discharge chamber and clearance spaces. For a given discharge and speed, the head through which water may be pumped increases with the angle of the vane. There is, however, a certain angle at which the pump will show the greater efficiencies throughout a range of heads.

(7) The characteristic, that is, the relation between head, discharge, and speed of a centrifugal pump, may be expressed within a satisfactory close approximation, by a mathematical expression of the following form:

$$h = \frac{K_1 D^2 N^2}{2g} + \frac{K_2 Q^2}{2g\,A^2} + \frac{K_3 D\,N\,Q \cos \alpha}{2gA}$$

in which = total head including friction through which the pump will elevate water.

$2g$ = twice the acceleration due to gravity = 64.4

D = diameter of impeller in feet.

N = speed in revolutions per minute.

A = total area of water ways through impeller in square feet.

Q = quantity of water pump will discharge in gallons per minute or cubic feet per second.

α = angle made by impeller vane with tangent to rim of impeller, and

K_1 —K_2 —K_3 are constants which vary in sign and amount with the type of impeller, shape of discharge chamber and clearance spaces of the pump, and which may thus apply only to the pump for which they were determined. A factor making the equation applicable to any pump may be possible of determination when the nature and variation of the losses occurring within the pump are more definitely known.

Equations for three of the pumps tested were derived and are as follows:

2½" Pump, Serial No. 1—$h = .00366\,D^2N^2 - 9.15\,\frac{Q^2}{2g}\ \frac{}{2gA^2}$

$.0091\,\frac{DNQ \cos \alpha}{2gA}$

4" Pump, Serial No. 3—$h = .003355\,D^2N^2 - 9.31\,\frac{Q^2}{2g}\ \frac{}{2gA^2}$

$.00947\,\frac{DNQ \cos \alpha}{2gA}$

4" Pump, Serial No. 10—$h = .00336\,D^2N^2 - 2.949\,\frac{Q^2}{2g}\ \frac{}{2gA^2}$

$.0208\,\frac{DNQ \cos \alpha}{2gA}$

BRIDGE COMPANY TO BUILD NEW SHOPS.

The Dominion Bridge Company have decided to locate their western plant at Calgary, Alta. The Calgary plant will be larger than the Winnipeg plant of the company. The board of directors of the company had about decided to triple the size of the Winnipeg shops, which at present employ between 300 and 400 men, but upon considering the matter, they decided to look to Calgary, as the greater bulk of their western business lay west of Winnipeg, Man.

A REINFORCED CONCRETE BRIDGE.*

By J. H. de Warrenne Waller.

The subject of this paper is a bridge, of the flat beam-and-slab type, that spans a branch of the River Lee passing through the grounds of University College, Cork, Ireland.

It is hoped that a description of the work may prove interesting, not because of the size or importance of the undertaking, but rather because its construction presented a problem commonly met with in everyday engineering practice—i.e., the construction of a thoroughly economical structure, and yet one of good appearance.

The bridge is seventy-two feet long, sixty-eight feet between abutments, and has a pier in the centre of the span. The roadway is sixteen feet wide.

The old bridge was built of Oregon pine, and had been in service about twenty-seven years. During that period it had been frequently repaired, the estimate for painting and renewals has been put at $82.79 a year. It was found on examination to be quite rotten and beyond repair. With a view to re-construction, the Governing Body of the College invited four steel firms to submit designs and estimates for steel bridges, and the author was permitted to submit an alternative design in reinforced concrete. The competitors were allowed to employ one or two spans, and appearance was to be taken into account. A plain plate girder bridge would not be considered.

The designs were to be made for a moving load of six tons on four wheels, the axles being six feet long and eight feet apart, and in addition a uniformly distributed load of fifty pounds to the square foot. The working stresses in the structural steel were not to exceed those usually used in this class of work.

The stresses on the reinforced concrete design were not to exceed 14,000 lbs. per inch in mild steel in tension, or 600 lbs. on concrete in compression. All the tension was to be carried by the steel. All calculations for the reinforced concrete design were to be submitted to the Governing Body.

Of the four steel firms invited, two sent in designs. The first was in a single span, and was to cost $2,191.24, erected complete on foundations prepared by the purchaser, but exclusive of any mason work or road filling. The second was in two spans, and was to cost $1,290.55, erected complete, but not including cost of cartage from quay to site, concrete for roadway, paving of road, pier in centre, or preparation of abutments.

The reinforced concrete bridge, exclusive of these items, cost $1,147.33.

Now, coming to the particular system adopted, it will be seen in Figs. 4 to 9 that the reinforcement used is plain round bar. This was used in preference to square bar, as it was believed to be the cheaper and the more readily obtainable. Subsequent experience has shown that this is not so, and in other works the author has used square bar because:—

1. It has superior bonding power to round bar, as the surface area is greater in proportion to its cross-sectional area.

2. The square form makes it more easily bent true, and so there is no inconvenience caused by bars getting "in winding."

It will be noticed on looking at Figs. 4 and 5, there is only one pattern of bent bar in each beam.

The bottom layer of bars are made to overlap a distance of six feet at the support; the object of this being to provide

*Abstracted from a paper in Trans. Inst. C.E., Ireland 1911.

against tensile stresses which might be caused in the bottom of the beam over the support if the central pier sank. These bars, it will be noted, are very long, and had to be welded—the welds were only allowed where the stresses were light, as shown in Fig. 5.

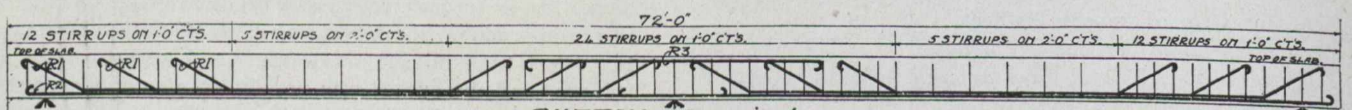
All the bars over three-quarter inch diameter are terminated in a round crook instead of the more usual right angle crank or fish-tail—an investigation of the bond stresses near the end of a large beam would indicate that this extra precaution against slip is justifiable.

In connection with the main beam bars the spacing is worthy of attention. The two layers of steel are not placed directly one on another, as is customary in many of the systems in vogue, but are kept separate by one inch of concrete; this is to make provision for the transmission of the stress in the steel to the concrete.

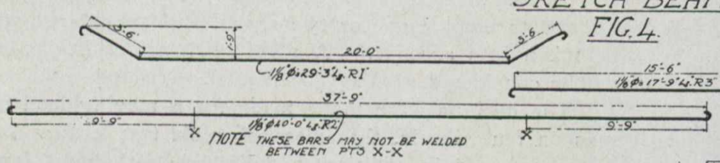
One of the most important questions about any system is that of the thickness of concrete allowed as protection for the steel. Two-inch cover has been allowed on all the main beam reinforcement.

such a position that the cranked end of the stirrup can hook over it. Both these forms of stirrup have the disadvantage that the ends pierce the surface of the concrete, and in some cases would undoubtedly cause a blemish. This difficulty may be easily overcome wherever necessary by casting beforehand some small concrete blocks, about an inch high, and placing them under the ends of the stirrups, so as to give the requisite cover. In most situations, such as indoor work, this precaution is unnecessary, and in the case of the underside of this bridge it was considered that if slight rust spots appeared they would not be detrimental to the work.

In the bridge the specification required the concreting of the slab and beams to be done in one operation. It is not usual in the United Kingdom to impose very stringent conditions as to the number of joints formed, it being considered sufficient to require all vertical joints to be made at the centres of span. It is further usual to specify that, when new concrete is to be joined to old, the surface of the old concrete shall be "roughened" and coated with grout before the new concrete is applied.



SKETCH BEAM 'B1'
FIG. 4.



STEEL DIAGRAMMS BEAM 'B1'
FIG. 5.

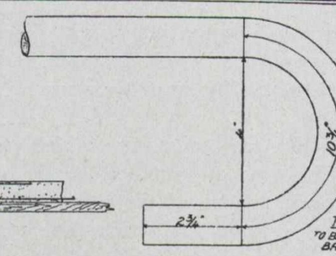


FIG. 6
TYPICAL CROOK
TO BE ON ENDS OF ALL BARS OVER ¾" DIA.

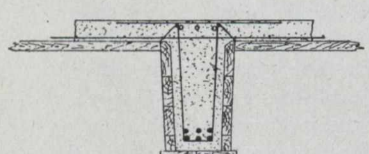
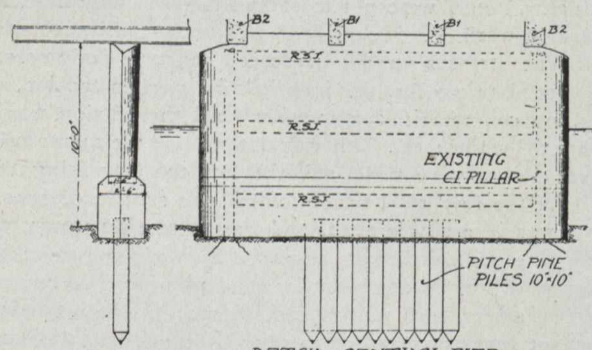
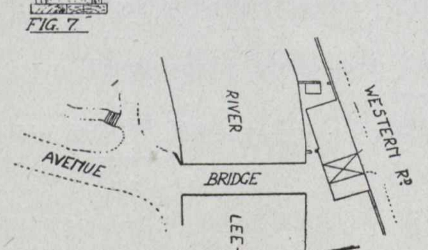


FIG. 7



DETAIL CENTRAL PIER.
FIG. 8.



PLAN OF SITE
FIG. 9.

The main points affecting the question of steel protection would appear to be:

1. Ample proof has been furnished as to the capability of well-proportioned reinforced concrete to sustain the loads for which it was designed.

2. Concrete is not absolutely waterproof.

3. The silicates of iron formed on the surface of steel embedded in Portland cement concrete have been found by M. Breuillie to be soluble in water.

4. The practical difficulty of placing steel exactly in the position laid down by the designer is so great that it is not safe to calculate on the steel being, in all cases, nearer than one half an inch on one side or other of the position called for on the plan.

The stirrups were made from plain three-eighth inch steel. The ends of the stirrup rest upon the forms, and so not only is it self-supporting, but is an excellent means of holding the main bars in position.

The stirrups in the two outside beams are a modification of those in the central beams. It will be noticed that only one side of these stirrups rests on the forms, the other side is best supported by means of a deal fixed temporarily in

Calculations.—The lay-out of the beams was fixed provisionally; the bending moments were then calculated, and diagrams of bending moment accurately prepared. The two outside beams were considered as rectangular beams in which the depth was fixed, being the height from the top of the curb to the level of the bottom of the central beams. All calculations were based on the assumptions that the modulus of elasticity of steel is fifteen times as great as that of concrete, and that the distribution of compressive stress followed the straight line law.

The web-stresses were investigated in the usual way, but considerably more web-reinforcement was allowed than the actual stresses called for, as, in all beams subjected to the vibration of traffic, it is most advisable to thoroughly bind the upper and lower parts together, whether the stresses developed in quiescence demand it or not.

The bending up of half the main bars was effected as soon as the reduced bending moment, as shown by the bending moment diagrams, would allow; the bars were bent up at an angle of 30 deg. to the horizontal.

The difficulty of ornamenting this type of bridge is not easily overcome. Sometimes the side beams are perforated, but in this case they contained sunk panels. The balustrade was made the main ornamental feature and a diamond-shaped lattice panel adopted. In the centre are placed the College arms, which were beautifully modelled in clay and reproduced in neat cement.

The proportions of the concrete were on the usual 1:2:4 mix, but provision was made in the specification for varying the proportions within certain limits. Thus, should the 1:2:4 mixture prove too lean in mortar the proportion of the coarse aggregate might be lessened by an amount not exceeding 12½ per cent., and a similar reduction might be made in the sand if the mortar should prove excessive.

The coarse aggregate used was a mixture containing one part of one inch hand-broken stone and two parts of river gravel, which was screened through an inch screen, and failed to pass a quarter inch screen.

The sand required neither washing nor screening. The cement was required to pass the standard specification, and, in addition, a tensile test on briquettes at the end of three days of 250 lbs. in^2, and the usual pat tests for soundness.

The concrete was gauged with sufficient water to enable it to flow slowly when agitated. No heavy ramming was necessary (or possible) with a mixture as wet as this, but the concrete was thoroughly worked with pieces of batten sharpened to a chisel point at one end. Great care was taken in placing the concrete to avoid air voids and to produce a good surface. The concrete in the barrows was always dumped on that already in position, and then was made to flow forward into position. If the forms are kept well wetted and the concrete is placed in this way a small amount of the fine stuff flows on just in advance of the main body of the concrete, which rises gradually in the forms, effectively preventing air bubbles being imprisoned next to the forms.

It is most important to keep all form work quite wet while concrete is being placed, as dry forms, and especially dry forms which are also greasy, enable the air bubbles to stick to the timber. With well-spaded, wet concrete pockets or voids can only occur when there is a leak in the forms and mortar is allowed to escape. The use of soap or oil on the forms is not recommended unless very sparingly applied, as there is always danger of its getting on the steel and destroying the bond. A wash made from marl or "killed" plaster of Paris is to be preferred. The concrete was all mixed by hand.

In the central pier the concrete under water was placed by means of a six inch by six inch wooden chute. The concrete was put in dry at the top, the lower end of the chute was then lifted gently off the bottom, and the concrete allowed to flow gently into position; the chute must always be kept well filled, so that no concrete may fall directly into the water. It is necessary when placing concrete under water to take extra precautions to have the forms as tight as possible, as quite a small hole or crack will allow the cement to escape. In spite of carefully-made forms two places, where this had occurred, appeared when the forms were stripped; to amend these defects the spots were thoroughly hacked out and then plugged with small bags, made of common calico, half filled with cement and sand in equal parts. The result was quite satisfactory.

The lattices were not cast in situ, but were made separately in special forms. These forms were made in halves, each half having a bevel of a quarter of an inch towards the centre, so that they could be readily drawn without injuring the arrises of the lattices. The concrete in the lattices was made out of limestone crusher-run and cement in equal parts; they were taken out of the moulds three days after casting. The balustrades were each cast in one operation; the lattices and ornamental shields were placed in position, the forms for the pillars, posts, and top-rail were fitted closely around them, and then the whole concreted up.

As stated before, the two end supports of the old bridge needed very slight alteration. The central supports of the old bridge were cast-iron pillars, and were not suitable for the new design, but as they were well founded it was deemed unnecessary to remove them, and they were left in position and incorporated in the present central concrete pier. In between these columns were driven ten 10 inch by 10 inch pitch pine piles, which were cut off below low water mark; these piles are relied upon to carry the main load of the structure.

Road Surface.—The surface adopted for the road was Staffordshire blue paving brick. The bricks rest on a filling of breeze concrete, which absorbs the vibration and renders the roadway less noisy than brick on rock concrete. Such a surface looks well and is much cheaper than blocks or asphalt.

Before placing the cinder concrete the top of the floor slab was thoroughly cleansed and coated all over with three coats of coal tar thinned with paraffin oil. The tar was completely absorbed by the concrete as the weather was hot.

Cost.—The structure complete cost $1,954.24, including fees for design.

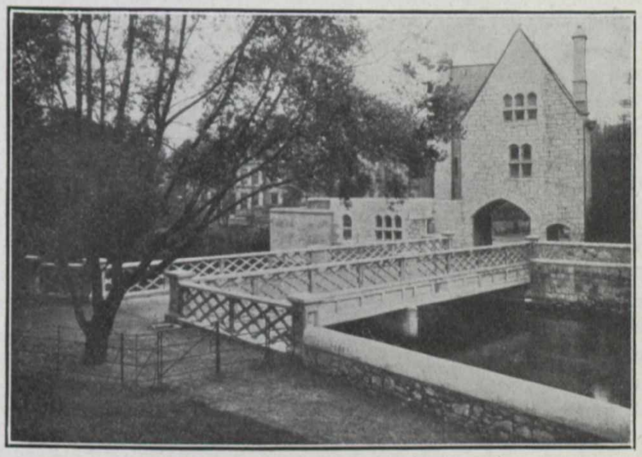


Fig. 1.—Reinforced Concrete Bridge.

The cost is made up as follows:—

Central pier, including 10 piles; 9 cubic yards of concrete, including forms	$258.11
Concrete in the body of the bridge at 50s. per cubic yard, including forms	$555.18
Steel (complete reinforcement) at £14 per ton, bent and in place	$267.85
144 feet run of balustrade, excepting ornamental shields, complete in place	$206.70
116 yards super. Hamblet's No. 23 paving brick, including breeze concrete	$253.24
Other items	$413.16

In conclusion, a few general remarks about this type of bridge may be of interest.

Beam-and-slab bridges in spans up to fifty feet are very economical. The forms are cheap, there being little or no curved work. The stresses are more definitely determinate than in arched work, which enables the designer to economize in materials. The abutments are cheaply constructed and certain in action, as there is no oblique thrust. One of the most economical features, however, is the floor slab, which performs two distinct duties:—

1. As the floor slab it transmits loads transversely to the beams.

2. As compressive flange of the beams it transmits the loads longitudinally to the abutments.

Thus there are two distinct sets of compressive forces acting at right angles to each other in the slab.

For economy in design the beams should be so spaced that there is just sufficient floor space available to form the flanges of the beams. Such bridges are particularly suitable for carrying roads over streams and railways; the heavier the loads they are designed for, the greater the economy, since the relative dead weight of two such bridges is in favor of the heavier design, while the cost of upkeep will not be greater for the heavier than for the lighter design.

The life of such bridges should at least be as long as a stone arch, and with liberal design and, most important of all, careful construction the cost of upkeep should compare very favorably with the most beautiful of all bridges—the stone arch.

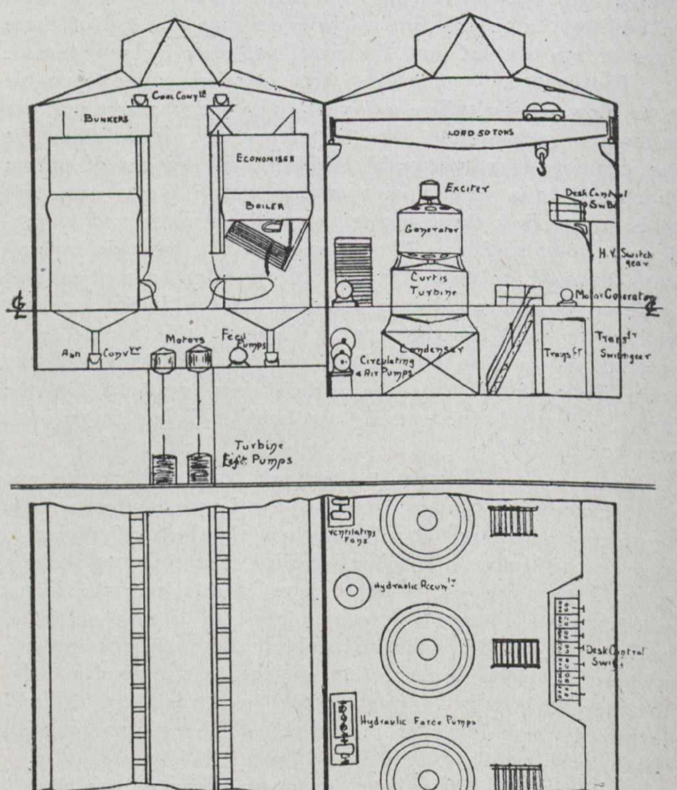
THE DESIGN OF ELECTRICAL POWER STATIONS.*

By A. H. Perrett.

It is probably the aim of every engineer to obtain a high degree of economy in the plant under his supervision, but even the highest yet obtained is comparatively small. At present we utilize as useful work much less than 10% of the total energy in the coal, while we make no attempt to recover any of the valuable by-products which in the form of fixed nitrogen would produce a fertilizer at such a price as would completely revolutionize the agricultural industry. If coal is to be burned economically and these by-products recovered it would appear to be fundamental that the energy in the coal should be converted at as few centres as possible into a form in which it is most generally applicable to all purposes without exception, and in which it is most easily applied to all our wants, and is, at the same time, in a form in which it is most difficult to waste or use improperly. We are, therefore, forced to the conclusion that the only complete and final solution of the question is to be obtained by the conversion of the whole of the coal which we use for heat and power into electricity, and the recovery of its by-products at a comparatively small number of great electricity producing stations. The effects of such a scheme as this one which has been proposed by Mr. de Ferranti would be far-reaching. The economy of stations would go up to a degree hardly dreamed of, and the price of electricity would fall to such a value as would prohibit the use of other forms of power even if this were desired. The advantages of such a system might be enjoyed in part if electricity could be produced at a cheaper rate than at present obtains. A very large proportion of the charges for electricity are due to interest on capital charges, and if these could be reduced by compromising space in any way it would materially reduce the cost of electricity. One cannot help being struck upon entering some power-houses by the apparent great waste of space, floor space and head room. It is the object of this paper to enquire into this apparent waste of space and to suggest certain re-arrangements of plant which will economize space. The problem of present-day power station design is far more complicated than was the case a few years ago, and this is contrasted in the paper. Recent additions to the plant of an electric power station and ones which greatly assist in the economical running are next dealt with, including the Tirrill regulator, the Lea water recorder, and the Davis-Perrett patent oil eliminator, which are briefly described. From numerous examples of power station design certain principles are next deduced and suggestions are made for economizing space. From these suggestions the plans of an imaginary station are drawn up, in which are embodied the principles and suggestions deduced. In conclusion, attention is drawn to the use of ice-making machinery for improving the load factor of the plant. This idea is extensively carried out in America, beside improving the load factor with all the attendant advantages the ice is sold at a profit. The suggestion is made that this idea might be extended and applied in this country to electro-chemical and electro-metallurgical processes. In all there are three definite points raised for discussion in the paper:

1. The amount of space which should be left for dismantling the machinery. The author suggests leaving room for dismantling one-third of the plant at one time without overcrowding the working space.

2. The plan of the imaginary generating station and the suggestions embodied therein.



Plan of Imaginary Generating Station Suggesting Certain Economies in Space.

3. The use of electro-chemical or electro-metallurgical plant for increasing the load factor of the station.

The suggested plan of a generating station is shown below. Each unit is absolutely complete in itself with boilers, economizers, condensers, circulating and air pumps, and high voltage switchgear, although sufficient and suitable valves are provided for interchange parts during breakdown. The turbines are vertical Curtis type placed above the condenser with the generators on top. An observation gallery runs the whole length of the station with the high voltage switchgear arranged immediately below it. The transformers and their high voltage switchgear are placed below the floor line and are accessible to the crane through trap doors in the floor. The whole of the switchgear is controlled from a desk type board, situated in a bay, on the observation gallery. The chief alterations in design of the boiler-house are the placing of the economizers on the top of the boilers, a method which is adopted in one large generating station in London. The Schulz economizer, which is just being

*Abstract of a paper read before the Northampton Institute Engineering Society, Nov. 17, 1911.

introduced in this country, appears to be specially suitable for this purpose. Turbine feed and lift pumps are employed, as these have special advantage in small repair bill and quickness with which they may be started. The whole of the auxiliary throughout are driven by electric motors, the current for this purpose being supplied from the motor generator situated under the desk control board, this machine also supplying current for the electrical operation of the high voltage switchgear.

OPERATION OF WATER PURIFICATION PLANTS.*

Upper Roxborough Filters.—This station consists of a storage reservoir of 147,032,000 gals. capacity, giving a period of about 9.45 days' sedimentation, eight covered filter beds of a combined area of 5.6 acres and a covered clear water basin of 8,000,000 gals. capacity. During the year there were filtered at this station an average of 13,884,000 gallons per day, corresponding to an average rate of 2.479 million gallons per acre per day. The cost of operation was $3.09 per million gallons, of which the laboratory cost was 47 cents per million gallons filtered. This includes all the items connected with the operation of the station, but does not include the cost of pumping water from the storage reservoir or sedimentation basin to the filters.

Comparing the filtered water and the water flowing from the Upper Roxborough sedimentation reservoir, the reductions were as follows:

	Per cent.
Average reduction, turbidity	99.83
Average reduction, bacteria	99.30

Comparing the effluent from the filters with the water pumped from the Schuylkill river the reductions were as follows:

	Per cent.
Average reduction, turbidity	99.93
Average reduction, bacteria	99.91

The total number of runs or cleanings during the year was 62, an average of 7.75 runs to each filter, the average time between scrapings being 43.44 days. The average amount filtered between cleanings was 80.63 million gallons, or 115.183 million gallons per acre.

Three methods of washing were used during 1909 and their average runs were as follows:

	Average days each.
Scraping and ejecting, 1909, 16 runs	43.7
Brooklyn method, 1909, 18 runs	55.4
Nichols separators, 1909, 31 runs	41.6

and the cost of labor and wash water was respectively 49 cents, 28 cents and 61 cents per million gallons of water filtered, or an average price of 48 cents. The average amounts filtered between runs for the three above methods of washing were 90.2, 85.7 and 74.9 million gallons, and the wash water required was 2,200, 1,300 and 1,200 gallons per million gallons of water filtered, respectively.

This year (1910) but two methods were used, i.e., the Brooklyn and Nichols, and the results were as follows:

	Average days each.
Brooklyn method, 33 runs	41.55
Nichols separators, 29 runs	45.60

The cost of labor and wash water was respectively 65 cents and 98 cents per million gallons of water filtered, and the average amount filtered between cleanings was 113.5 and 117.0 million gallons per acre. The wash water required was 2,144 and 2,370 gallons per million gallons filtered, respectively.

The storage reservoir from which these filters are supplied is so large that the water was subsided for an average of 9.45 days before going upon the filters. The results obtained from this sedimentation are very good. The average turbidity of the water before being stored was for the year 37, while the effluent from the reservoir averaged 14.

The percentage of reduction in turbidity was 61.2 per cent., and the reduction in bacteria from the above storage was 87.54 per cent. The maximum turbidity of the raw Schuylkill river water at the Roxborough station was 950, the minimum 5, and the average for the year 37.

The average bacteria in the Schuylkill river at Shawmont location of the pumping station supplying water to this plant was 77,800, the minimum 3,900, and the maximum 460,000.

Lower Roxborough Filters.—This station consists of a storage reservoir of 12,838,000 gallons capacity, giving a period of 1.59 days' sedimentation; five covered filter beds, having a combined area of 2.65 acres; eleven preliminary filter tanks, with a combined area of 0.2586 acres, and a covered clear water basin of 3,000,000 gallons capacity.

During the year there were filtered at this station a daily average of 9,362,000 gallons, corresponding to an average rate of 3.533 million gallons per acre per day. The filters were operated at rates between five and six million gallons per acre per 24 hours.

The cost of operation, including the preliminary filters but not including the cost of the wash water, was $4.82 per million gallons filtered, of which the laboratory cost was 69.6 cents per million gallons, filtered.

The preliminary filters were operated at an average rate of 45,220,000 gallons per 24 hours per acre, at a total cost of $1.23 per million gallons of water filtered by the sand filters. The cost of labor and wash water was 68 cents, replacing slag and furnishing new sponge cost 37 cents per million gallons. The average turbidity of the applied water for the year was 24, and the effluent averaged 12, the average reduction in turbidity being 51.4 per cent. The removal of bacteria by the preliminary filters for the year averaged 41 per cent.

The maximum quantity filtered by the sand filters in one day was equivalent to a rate of 5.58 million gallons per day per acre in service. The filters were washed for the entire year by the "Brooklyn" method. The total number of runs or washings of the sand filters for the year was 65, an average of 13 per filter. The average time between scrapings was 25.19 days, and the average amount filtered between cleanings was 97.65 million gallons per acre.

There was no resanding during the year.

Comparing the filtered water and the effluent from the preliminary filters, the reductions for the past year were as follows:

	Per cent.
Average reduction, turbidity	99.42
Average reduction, bacteria	98.80

In the following table a comparison is made, showing the reduction of the bacteria and turbidity in the water received from the Schuylkill river. This is the work of the combined plant, consisting of a sedimentation basin (where

*Extracted from Report for 1910 of Chief of Bureau of Filtration in Philadelphia, Pa.

the water is allowed to stand for an average period of 1.59 days), preliminary filters and the final filters:

	Per cent.
Average reduction, turbidity	99.81
Average reduction, bacteria	99.58
Maximum reduction, turbidity	100.00
Maximum reduction, bacteria	100.00
Minimum reduction, turbidity	98.00
Minimum reduction, bacteria	98.00

Belmont Filters.—The Belmont Filter Station is composed of a sedimentation basin of 70,000,000 gallons capacity, giving a period of 1.8 days' sedimentation; preliminary filters consisting of nine filter tanks, having a capacity of 40,000,000 gallons per 24 hours; 18 covered sand filters, having a combined area of 13.23 acres, and a covered clear water basin with a capacity of 16,500,000 gallons.

The filters are operated at a nominal rate of 3,000,000 gallons per acre per 24 hours, and the quantity filtered during the past year was at an average rate of 2.857 million gallons per acre per 24 hours.

The maximum amount of water filtered in any one day was 43,815,000 gallons, equivalent to a rate of 3.24 million gallons per acre per day of filters in service.

The preliminary filters were started on October 23, 1907. They were operated at a rate of 75,000,000 gallons per acre per 24 hours this year, and have materially increased the length of runs or time between scrapings of the slow sand filters without any decrease in efficiency.

The cost of operation was $2.86 per million gallons filtered, which included the cost of preliminary filtration at 53 cents per million gallons and the laboratory charge at 24 cents per million gallons.

The reduction in turbidity and bacteria by the action of the preliminary filters was 50.14 per cent. and 44.5 per cent., respectively.

There were 156 runs or cleanings during the year; 139 of these runs were on filters cleaned by the Brooklyn method and 17 by the other methods.

The average length of runs was 40.58 days, the amount filtered between runs being 89,130,000 gallons, or 118,522,000 gallons per acre.

While the length of runs and quantity filtered with the Brooklyn method was not so large as with the usual method, it proved economical on account of the short time it was necessary to have the bed out of service, the low labor cost of cleaning, and the saving in not having to replace the sand.

Sixteen filters were operated for the entire year by the Brooklyn method. The items of cost, etc., in the process of cleaning were as follows:

Number of runs	139
Average length of runs, days	41.1
Average m. g. filtered per run	91.25
Average m. g. filtered per acre per run	121.34
Average cost of water to wash per m. g. filtered	$0.05
Average cost of labor to wash and spade per m. g. filtered	0.44
Total cost of washing and spading sand in place (water and labor) per m. g. filtered	0.49
Average gallons water used to wash sand in place per m. g. filtered	3,480

One filter was cleaned by raking, spading and ejecting to the court in the usual manner for the entire year. The items of cost, etc., were as follows:

Number of runs	9
Average length of runs, days	39.05
Average m. g. filtered per run	87.63
Average m. g. filtered per acre per run	116.53
Average cu. yds. sand scraped per m. g. filtered	1.05
Average cost to scrape per m. g. filtered	$0.50
Average cost to remove per m. g. filtered	0.16
Average cost to wash per m. g. filtered	0.05
Average cost to scrape, remove and wash per m. g. filtered	0.71
Average cost to clean, including replacing sand, per m. g. filtered	0.99

Another filter was operated during the year by the "Nichols Separators" method.

Number of runs,	8
Average length of runs, days	28.04
Average m. g. filtered per run	58.52
Average m. g. filtered per acre per run	77.82
Average cost of labor, scraping, raking and spading per m. g.	$0.282
Average cost of washing per m. g. filtered	0.406
Average cost of water per m. g. filtered	0.03
Average cost per m. g. labor, spading, scraping, washing, water, etc.	0.72
Average gallons water used to wash per m.g. filtered	1,905
Depth of sand scraped per run	1.08
Cu. yds. sand scraped per m. g. filtered	1.813
Daily average turbidity of applied water	11.00
Daily average bacteria in applied water	18,330

In six filters a total of 1,430 cubic yards of sand were placed during the year by Bureau labor with the use of the Nichols separator, at a cost of 44 cents per cubic yard. Comparing the effluent from the Belmont Filters with the applied water, the reductions were as follows:

	Per cent.
Average reduction, turbidity	99.39
Average reduction, bacteria	99.00

Comparing the effluent of the plain sand filters and the water from the Schuylkill river, the reductions were as follows:

	Per cent.
Average reduction, turbidity	99.78
Average reduction, bacteria	99.64

A Blaisdell Filter Washing Machine installed in 1909 for cleaning the preliminary filters has been in operation for the entire year and has been of great benefit to the filters.

Torresdale Filters.—The Torresdale Filter Station consists of sixty-five 0.75 acre covered beds, a covered clear water basin of 50,000,000 gallons capacity, preliminary filter plant consisting of 120 concrete tanks, approximately 60 x 20 feet, and containing 1,140 square feet of filtering surface, with a capacity of 240,000,000 gallons of water per 24 hours; a low lift pumping station, containing eight 40,000,000-gallon centrifugal pumps; three 150 kw. generators and four sand washing pumps, with full complement of boilers, economizers, mechanical stokers, etc.

The amount of water filtered during the year was at a daily average of 4.18 million gallons per acre per day.

The entire cost of operation, not including the expenses of the low lift pumping station, or the cost of the wash water, which are included in the expenses of the pumping station, and which amounted to $2.17 per million gallons of water filtered, was at the rate of $1.82 per million gallons of water filtered, making the total expense of pumping the water from the river and filtering it $3.99 per million gallons filtered.

Of this amount $0.30 was for operating the preliminary filters and $0.186 for the cost of the laboratory, per million gallons filtered, respectively.

The filters are operated at rates approximating 6,000,000 gallons per day per acre.

The maximum amount filtered in any one day was 229,000,000 gallons, equivalent to an average rate of 4.86 million gallons per acre per day for the area in service.

The total number of runs or cleanings was 651, an average of about ten cleanings per filter per year, and an average length between cleanings of 33.65 days.

The average quantity filtered between runs was 113.97 million gallons, equivalent to 162.77 million gallons per acre per run.

The standard method of cleaning adopted for 1910 was washing the sand in the filters by ejectors and Nichols Separators, the cost of which was as follows:

Number of cleanings by Nichols method	558
Average length of runs, days	35.19
Average million gallons filtered per run	118.28
Average million gallons filtered per acre per run	144.53
Cost of water to wash per million gallons	$0.01
Cost to rake, scrape and wash per million gallons	0.65
Total cost to clean	0.66
Average gals. water used to wash per million gals.	2,027
Cubic yards scraped per million gallons filtered	1.67
Average turbidity of applied water	8.00
Average bacteria in applied water	2,220

At the beginning of the year, owing to the extreme, long-continued turbidity of the Delaware river water, and also the fact that nearly all the filters were operating at a comparatively high loss of head when the turbid condition of the water occurred, it was necessary, in order to keep the filters in service, to work a night force on cleaning filters for some time.

The filters were cleaned at this time in the usual manner, by scraping and ejecting and washing in the courts, and the costs, which were naturally high, are as follows:

Number of runs	93
Average length of runs	24.46
Average million gallons filtered per run	88.18
Average million gallons filtered per acre per run	105.21
Average cubic yards scraped per run	231.50
Average cu. yds. scraped per million gallons filtered	2.63
Average cost to scrape per cubic yard of sand	$.015
Average cost to remove and wash per cu. yd. of sand	0.27
Average total cost per cu. yd., including water	0.43
Average total cost per million gallons to clean filters, including water	1.14
Average total cost per million gallons to clean filters and replace sand, including water	1.80
Average gallons water used to remove and wash per cubic yard sand	2,850

There is quite a difference in cost between the two methods, but this was due largely to the circumstances; the work was done under emergency conditions continued night and day in extremely bad weather with turbid water that naturally shortened the amount filtered between cleanings.

The total cost of cleaning under emergency conditions was $1.80 per million gallons filtered while under normal conditions and water, the average cost for the year was but $0.66 per million gallons filtered.

The total cost of operating the entire filter station, including superintendence, supplies, repairs, cleaning, laboratory, pre-filters, lighting, wash water, but not the low service pumping station, during September, 1910, was $1.39 per million gallons filtered, of which $0.30 was for preliminary filtration and $0.16 for the laboratory, and but $0.43 for cleaning filters. The water previously and during this month was good, a large amount was filtered between cleanings and the cost was correspondingly low.

To guard against the trouble experienced at the beginning of the year, the filters after November 1st were cleaned in rotation and even with the water then applied, they would have filtered many million gallons more before it was necessary to put them out of service; in other words, the loss of head on all the filters was after that date kept low, so that when the period of turbid water occurred a large number of the filters would not go out of service at one time.

The resanding was done during the year by Bureau labor, using the Nichols Separators, a total of 13,717 cubic yards were replaced in filters at a cost of 25¼ cents per cubic yard.

Comparing the effluent from the Torresdale final filters with the water taken from the Delaware river, the reductions were as follows:

	Per cent.
Average reduction, turbidity	99.12
Average reduction, bacteria	99.36
Maximum reduction, turbidity	100.00
Maximum reduction, bacteria	99.93
Minimum reduction, turbidity	95.45
Minimum reduction, bacteria	98.40

The Torresdale preliminary filters were placed in service on January 21, 1909, and since this date all water filtered by the sand filters has passed through these filters. They normally filter at the rate of 80,000,000 gallons per acre per day, but have given satisfactory results from rates of 100,000,000 gallons per acre per day. The daily average reductions in turbidity and bacteria for the year were 67.4 and 68.5 per cent., respectively.

The average turbidity of the applied water to the prefilters was 25 and the maximum 260. The per cent. of wash water used for the year averaged 1 per cent. of the amount filtered.

The number of cleanings for the pre-filters was 40,119, an average of 334 cleanings to each filter, or about 1.1 days between cleanings for the year.

The total amount pre-filtered was 77,781 million gallons, requiring 778 million gallons of wash water.

BITUMINOUS ROADS.

Tar macadam has been used in towns and cities of Ontario with varying success. Some pavements have given good service and others built in an apparently similar way have failed. In the cities of Hamilton and Ottawa, much tar-macadam was laid some years ago, but the uncertainty attending its use has caused it to be discarded as a material for road-building. This is due in part to the lessened cost of asphalt which, because of its uniformity, is regarded as a safer material. In England, however, tar-macadam in several forms, is used with much success, and there is every reason to believe that, if scientifically employed, it can be equally serviceable in this country.

The New York State Highway Commission has probably built a greater mileage of bituminous-bound stone roads than has been built to date in the balance of the United States. The experience gained therefore would seem to be of value inasmuch as no failures of moment have been had. Nearly 1,000 miles of such road have been completed and there are now approximately 600 miles additional under contract.

THE HUMPHREY PUMP AND COMPRESSOR.

By William Young, B.Sc.

The name Humphrey Pump covers broadly the recent work of Mr. Herbert A. Humphrey, of London, in the field of internal combustion pumps and compressors employing a liquid piston. To date there is little literature on this subject, but (London) Engineering of November 18th, 1910, reprints a very complete paper read before the Manchester Association of Engineers by Mr. Humphrey, and the American Machinist of January 5th, 1911, contains an article by Mr. Edward N. Trump, of Syracuse, giving an account of his critical inspection and tests of the apparatus at the demonstration plant at Dudley Port, England, where all of Mr. Humphrey's developments have been made.

In this article it is intended to deal with the subject of pumps and compressors from the broad point of view, omitting all details as to type of valves and valve gear, except in several instances to illustrate the kind of devices that have been found suitable. If a definition of this new system were given it might read as follows: "a method of raising or forcing liquid which consists in applying the energy of expansion of an ignited combustible mixture to one end of a column of liquid so as to propel the column along a discharge pipe, and to cause it to oscillate in the pipe under such conditions of energy of the moving liquid, that everything necessary for preparing for the next ignition is performed during one or more oscillations and wholly or partly owing to it or them."

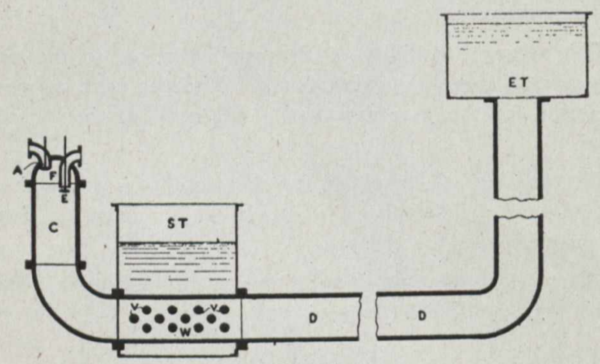


Fig. 1.

Take the simplest case of Humphrey pump, as illustrated in Fig. 1, water has to be raised from tank ST to an elevated tank ET. C is the combustion chamber, W the water valve box with valve V opening inwards, and D the discharge pipe. In the top of the combustion chamber are fitted an inlet valve A and an exhaust valve E. A simple interlocking gear is arranged between these two valves, so that when valve A opens and closes it locks itself shut and releases valve E. Consequently each time that suction occurs in the chamber these valves open in turn.

Imagine a charge of gas and air to be compressed in the top of chamber C, and fired by a sparking plug which projects through the top casting. All the valves are shut when expansion occurs, and the increase in pressure drives the water downwards in the pump and sets the whole column of water in the discharge pipe in motion. The column of water attains kinetic energy while work is being done upon it by the expanding gases, so that when these gases reach atmospheric pressure the column of water may be moving with considerable velocity. The motion of this column of water cannot be suddenly arrested, hence the pressure in C tends to fall below that of the atmosphere, the exhaust valve E opens, also the water valves V. Water rushes in through the water valves mostly to follow the moving column in pipe D, but partly to rise in chamber C in an effort to reach the same level inside the chamber as exists in the suction tank.

When the kinetic energy of the moving column has expended itself by forcing water into the high level tank, it comes to rest, and there being nothing to prevent a return flow, the column starts to move back towards the pump and gains velocity until the water reaches the level of the exhaust valve, which is shut by impact. A certain quantity of burnt products is now imprisoned in the cushion chamber space F, and the energy of the moving column is expended in compressing the gas cushion to a greater pressure than that due to the static head of the water in tank ET. Hence a second outward movement of the column results, and when the water reaches the level of valve E the pressure of the space F is again atmospheric, and further movement of the water opens valve A against a light spring and draws in a fresh charge of gas and air. If there were no friction the water would fall to the same level as that from which the last upward motion started, but the amount of combustion charge drawn in is slightly less than this movement would represent. Once more the column of water returns under the elevated tank pressure and compresses the charge of gas and air which is then ignited to start a fresh cycle of operations.

The action of the pump is not altered if, instead of delivering into an elevated tank, it discharges into an air vessel, or into an open top stand-pipe or tower and both these arrangements are useful if a continuous flow from an outlet is desired. In many cases the pump can be placed directly in a concrete pit, which serves also as a foundation and the discharge can be an inclined pipe, an arrangement that is very satisfactory and economical in material. By the addition of intensifiers, with discharge valves, all pumping problems are solved up to any head attained by steam pumps.

The valve gear is shown in Figs. 2 and 3. It will be observed that a bolt B sliding horizontally must lock either the admission valve A or the exhaust valve E by engaging under collars a or e, which are fixed on the stems of their respective valves. Now the bolt is urged right or left, according to whether spring S^1 or S^2 is pulling the hardest, and this again depends on whether link l to which the springs are attached has been shifted to the right or left. Suppose the exhaust valve opened last, then its washer m engaging against cam arm p moved the system p l q so that it leans to the right, in which position it is retained by the tension of spring S^3. This puts tension on spring S^1 and loosens spring S^2, bolt B therefore tries to move to the right, but until the exhaust valve shuts it can only press upon collar e. However, when E comes on its seat the bolt instantly locks under e, and the same motion which holds valve E shut has released valve A, so that next time a suction occurs in the combustion chamber A only can open. Precisely the same kind of action occurs when A shuts and is locked and E is released again. Thus valves A and E are automatically allowed to act alternately, the difference between them being, that while E remains open till shut by the rising water, A shuts under the action of its supporting spring as soon as the suction in the chamber permits the spring to lift the valve.

The scavenging valve V is shown in the plan of the combustion head (Fig. 3) and as it operates at the end of each expansion stroke its locking and release periods correspond with those of the exhaust valve, and are made simultaneous by a lever pivoted at K and operated by a pin on the bolt B. If the water could rush in fast enough when the pressure falls to atmosphere there would be no scavenging action, but the incoming water has to be accelerated, and that just gives rise to a sufficient suction to effect the desired scavenging. In the exhaust outlet there is a light non-return valve to prevent burnt products being drawn back into the chamber.

The ignition apparatus is such that ignition is determined by the compression pressure reaching the maximum incidental to each particular charge. It resembles an engine indicator consisting of a small piston acting against a spring. One form of it is fully described in the minutes of proceedings of the meetings of the Institute of Mechanical Engineers in London, between 19th November and 3rd December, 1909, (see page 1089).

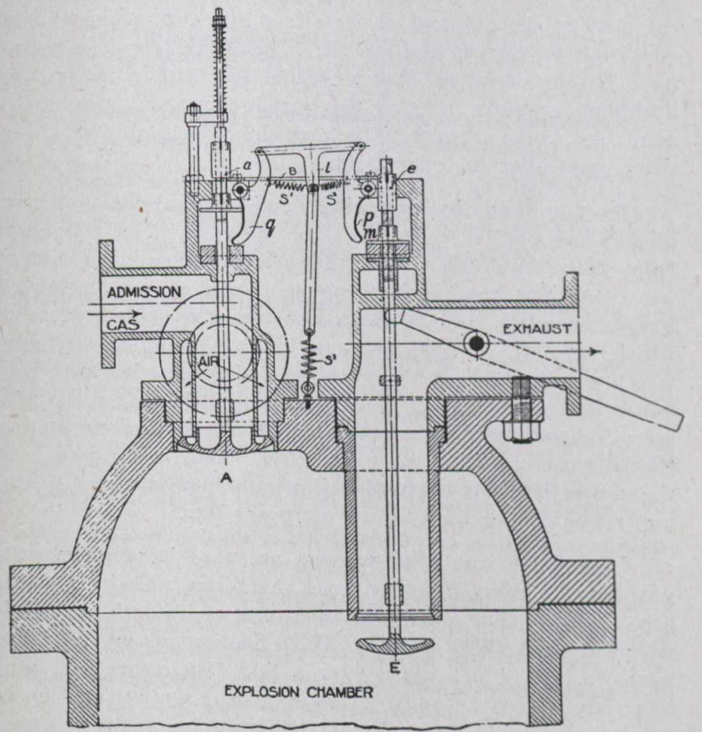


Fig. 2.

The Air Compressor.—If the column of water oscillating in the play pipe of a Humphrey pump is used as a water piston, and caused to rise and fall in an air vessel with suitable valves for the inlet and outlet of air, the combination constitutes an air compressor of a very efficient type and promising many advantages. Such a compressor in its simplest form is shown in Fig. 4. A is the ordinary pump chamber and C the air compressor chamber, and we may call them for convenience "the pump" and "the compressor" respectively. The inlet valve i for gas and air, and the exhaust valve e for burnt products exist as before, but the exhaust pipe and valve are adjustable vertically so as to vary the cushion space in the top A. There is another pipe p fitted with a valve r, and also adjustable vertically. A reservoir X such as an old boiler shell is connected by a flexible pipe to p. Corresponding parts are fitted to the compressor, thus f is an air outlet valve and h a non-return valve for the compressed air. The dip pipe q, with its valve s, gives communication between the atmosphere and the compressor. The outlet pipe and the dip pipe are vertically adjusted in the pump. Lastly, suppose the play pipe D filled with water, then we have all the elements required for working under the most varied conditions.

The cycle can be explained by assuming the water level is well up in A and low in C, as shown in the figure, and that a compressed charge is ignited in A. Expansion occurs driving down the water in A and up in C. At first air escapes from C through valve s, but when the water reaches this valve it is shut and the remaining air is trapped and suffers compression until the pressure of discharge is reached when h opens and compressed air is delivered. Next, the water reaches the valve g and shuts it so that no more air can escape, and the water column is brought to rest by the continued compression of the remaining air, which forms a cushion. Meanwhile in chamber A expansion to atmosphere allows the exhaust valve e to open, and the continued stroke draws in scavenging air (the scavenging valve being omitted from the figure for the sake of simplicity), but valves i and r remain locked. Now the column begins to return, due to the expansion of the compressed cushion in C, and this causes exhaust, and cushion in A and at the same time there is a fall of pressure in C to atmosphere, then valve f is opened against a light spring and a fresh supply of air enters.

So far we have had one outward and one return stroke, but the expansion of the cushion in A starts a second outstroke which results in drawing in a new combustible charge in A through valves i and r, which were released on the shutting of the exhaust valve e. As the second outstroke is nearly as long as the first, it follows that too much combustible mixture is drawn in, but the surplus is got rid of on the second return stroke by allowing it to escape into reservoir X and to slightly raise the pressure therein. Valve i was shut by its spring, but r waits to be shut by the action of the water, and when this occurs chamber A contains a definite volume of combustible mixture, the size of the charge being fixed by the height of r. Finally we have only to observe that the second outstroke towards C merely compressed the air in C without causing delivery to take place, but storing in the air the energy given out by the expansion of the cushion in A. The air in C now expanding gives the compression stroke in A, and the combustible charge is ready to be ignited to start the next cycle.

It will be evident that in the next cycle, when admission of combustible charge occurs, the surplus last rejected into the reservoir X will want to enter first because it is under slight pressure, whereas inlet valve i has to be sucked open against its spring, consequently X will empty to atmospheric pressure each time, and only the additional mixture required will be taken in through valve i. A slight modification may be made by transferring valve i from the pump to the reservoir X.

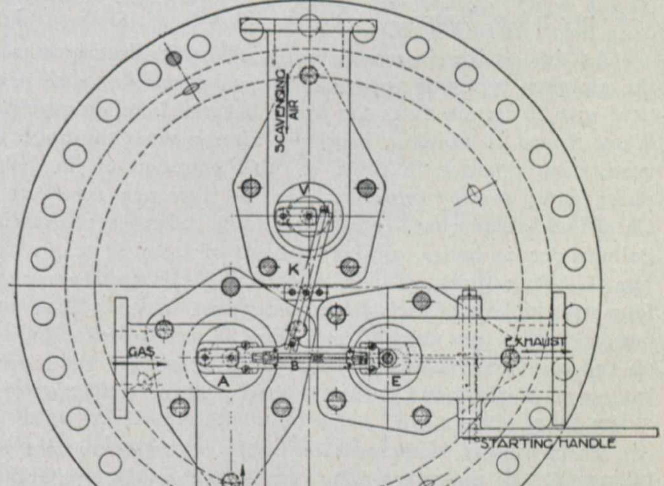


Fig. 3.

The flexibility of the air compressor is such that by means of valves g and s it is possible to compress a large volume of air to a low pressure or a smaller volume of air to a high pressure, or to make any intermediate changes that may be desired. Thus all the conditions of output, up to the full limit of the compressor may be governed at will and for all ranges the compression pressure of the new charge may be kept up to the required degree, so that the apparatus works at its maximum efficiency throughout the whole range.

On the question of efficiency it is of considerable scientific interest that the apparatus follows a cycle in which the expansion of the burnt products is carried to atmospheric pressure, and so involves a thermodynamic cycle of greater efficiency than can be claimed for the Otto cycle. In the proceedings of the Institute of Mechanical Engineers, London, this very important question is fully dealt with.

In his official test Dr. Unwin compares the Humphrey pump with other steam pumps as follows:

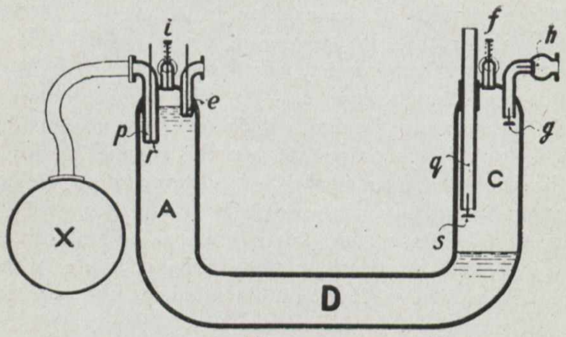


Fig. 4.

	High-Duty Worthington Engines Compound Nov., 1888	Triple Dec., 1896	Triple Feb., 1897	Humphrey Gas Pump Sept., 1909
Indicated horsepower ..	255.5	370.5	498.4	
Pump horsepower	217.1	320.3	449.8	16.15
Lift in feet	53.7	92.3	129.1	32.9
Quantity pumped in gallons per minute	13407.	11450.	11497.	1621.
Coal per i.h.p. hour ..	1.696	1.402	1.530	
Coal per p.h.p. hour ..	1.996	1.662	1.695	1.06

As this article is mostly occupied with descriptions of the simplest types of apparatus it will give it a more practical turn if certain facts are made known. The Metropolitan Water Board of London, England, after a most thorough investigation reported in favor of the adoption of the Humphrey pump for the pumping plant at their new reservoir at Chingford. The quantity of water to be raised is 180 million gallons per 24 hours, against a head of from 25 to 30 feet. For this duty there will be erected five Humphrey pumps, four of which will each have a capacity of 40 million and one 20 million per day. The saving in first cost is £19,000 on the complete installation, moreover, there will be a great saving in fuel consumption, it being about half that of a steam plant.

Firms of the highest standing in several countries are taking up the manufactory of the Humphrey pump, and to date pumps have been designed for use in Belgium, Great Britain and Ireland, Germany, Holland, Italy, India, Palestine, Roumania and the United States of America, also a number of compressors in the last named country.

THE SEWAGE DISPOSAL SYSTEM OF BERLIN, GERMANY.

The sewage disposal system in Berlin, Germany, is admirable, writes U.S. Consul-General A. M. Thackara from that city. No sewage is permitted to be discharged into the river or canals that pass through the city. It is all pumped through large pipes to the city sewage-farms (rieselfelder) located within a few miles to the north and south of Berlin. The farms have an area of about 40,000 acres, of which about 6,200 acres are leased in small holdings to farmers and the remainder cultivated by the municipal authorities.

While the city administration supervises the cleaning of the streets, the disposal of the sweepings and refuse gathered is left to various contractors. Some of these concerns have purchased barren and unproductive land to be used as dumping grounds, and as the garbage contains principally sand and horse manure, it is exceedingly valuable as a fertilizer and filler for such lands.

By law and by municipal police regulations, houseowners are obliged to provide for the removal of the waste from their buildings. For this purpose they have formed an association that includes most of the owners in Berlin. This association has made a contract for 30 years, 21 of which are still to run, with a limited liability company, which was formed for the purpose of disposing of household and other waste. They have erected a building for the purpose of handling the garbage, disinfecting it, and separating the different articles, such as metal, rags, and bones. All the refuse is then disposed of for fattening hogs, fertilizing, paper-making, or for grading purposes, etc.

Ingeniously contrived wagons are used in collecting the garbage. In every building large sheet-iron tanks or buckets are placed. The daily refuse is thrown into these tanks, which are capable of holding 100 or 200 pounds of ashes and garbage, and which close with a lid. The ashes and garbage are placed in separate receptacles. On certain mornings of the week the tanks are collected by wagons accompanied by three or four men. The wagons are large and tightly covered. A chain elevator is arranged so that a bucket can be placed upon a shelf on the side of the wagon and then raised and dumped into the wagon without permitting any of the dust to escape.

Ash-barrels or other such receptacles are not permitted on the streets in Berlin. The experiment of burning the organic waste of Berlin was tried, but it proved costly and unsuccessful and was given up.

RAILROAD FUEL.

Recent experiments regarding excessive fuel consumption were undertaken by the chief engineer of the Chicago Great Western Railroad. These investigations followed certain allegations of a prominent United States official, who made a statement to the effect that U. S. railroads were wasting $1,000,000 per diem through inefficient service. The results tended to show a wanton waste of $50,000,000 per year, and an expenditure of $200,000,000 to obtain $80,000,000 worth of efficiency, a further waste of $120,000,000. This is a total waste of $70,000,000 per year, or $465,750 per day.

The remedy suggested is a fuel bureau of experts, improved firing devices on locomotives, a school for firemen, more scientific ordering of locomotives, for service and closer watch on exposed coal yards.

In ten years United States railroads have increased the cost of their fuel supply from $104,926,000 to $213,828,000 per year.

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CITY BUILDING BY-LAWS.

There has been a good deal of discussion over the building by-law question in some of our larger cities. The building by-law and civic building inspection in Montreal has been severely censured from time to time, and no doubt rightly so. The present building by-law is a result of the addition of clauses, with no revision, which has been going on for many years. One clause in particular may be mentioned to illustrate how antiquated this by-law is.

Many years ago, before the days of matches, it was customary for the housewives of the town, when their fires had gone out, to get a light from their neighbors. This occasioned considerable danger, as the sparks from the burning coals were blown through the streets. For this reason a clause was added to the by-law prohibiting the carrying of lights or fire through the streets, and this clause still remains on the by-law. However, Montreal has appointed a strong committee to revise the by-law, and to outline changes in the department of inspection of buildings. This committee, composed of engineers and architects and those interested in the building trades, have gone into the matter most thoroughly, and the by-law, when finished, will be one of the best of its kind, either in United States or Canada. Toronto, on the other hand, although an application for the revision of the building by-law there was submitted to the City Council, about eight months ago, have done nothing to improve conditions. This proposed revision was compiled by the different representative bodies of engineers, architects, and the building trades, the Board of Trade, and Manufacturers' Association. These proposed changes were handed over by the Council to the City Architect for report, and as a consequence nothing has been done to the present time.

If Toronto had approached the problem in the same way as Montreal has approached it, by appointing a competent committee to revise the by-law, they would have secured some result. As a matter of fact, this procedure will in all probability have to be followed in the end, for the City Architect has as yet shown little desire to improve the by-law.

A DOMINION DEPARTMENT OF HEALTH.

The Canadian Public Health Association have just finished their first annual congress in Montreal. At this congress the Hon. Mr. Burrell, Minister of Agriculture, made the announcement that the Federal Government is about to establish a Department of Health. Of course, no details of this department are as yet available; in fact, from the Minister's statement the idea is very much in embryo as yet. A few weeks ago we noted that Premier Borden had announced himself as being in favor of Federal aid for good roads, and that there was a strong prospect of this aid being administered through a Department of Good Roads. These two departments, when they materialize, will be a decided step in advance, for both at the present time are most urgently required. At the present time, a Department of Public Health would confer great benefit upon the people by organizing experimental stations for investigations concerning sewage disposal and water purification. Also, there is need of a thorough campaign of education along hygienic and public health lines. In fact, the different activities in which such a department might interest itself are too numerous to enumerate.

However, in the establishment of such a Department of Health it must be remembered, in order to secure a maximum of benefit from its work, the engineer, as well as the public health officer, should be associated in the work. We see too many cases at present throughout the different cities of the Dominion of the injury caused by the separation of the duties of the Medical Health Officer and the engineer. There is a decided waste of efficiency when this condition occurs, for it is only by the closest association that the interests of each and of the public in general are best served. We would, therefore, suggest, in the establishment of this Department of Health, that the engineer be given adequate recognition in its make-up.

EDITORIAL COMMENT.

It is interesting to note the progress of the Good Roads Movement in the Province of Quebec. The total Government expenditure on roads in the older parishes amounted in 1905-6 to $9,661, while the sum appropriated for the current year is $250,000. This amount is likely to be largely exceeded by the rapidity with which the different municipalities are fulfilling the necessary conditions entitling them to a share in the Government aid.

* * * *

We have had occasion in these columns to note at different times the fatal results to be traced to carelessness in construction. This is again brought to our attention by an accident last week in Hamilton in which one man was killed and several injured. The accident, if such it may be called, was caused by the falling in of a concrete roof while the workmen were removing the forms from beneath. It appears that the concrete had been put in in freezing weather, with little or no protection, and that only a very short distance was allowed for over-lap on the beam connecting the new work to the old. Such culpable negligence is seen far too often at the present time. We need more rigid laws for the protection of life and property, and we need more strict enforcement of these laws when we get them.

* * * *

At the annual conference of the Municipal Tramways Association, recently held in Glasgow, one of the speakers laid down as the basic principle of a sound street railway policy the following points: First, to make the undertaking financially sound by building up a sufficient reserve and renewal fund, a consideration often neglected; two, the provision of sufficient accommodation and facilities for the travelling public, which includes both proper service of cars and cheap fares; three, to see that good conditions of labor are given to the workers; and four, when these three conditions are complied with, to see that the ratepayers, over whose streets the cars are run, and on whose credit the undertaking is financed and the capital is provided, get some return in the shape of a contribution to the rates. The above points, if followed, will undoubtedly give good results. However, this is very hard to secure in a municipal service. For instance, during last year thirty-four municipal street railway systems in Great Britain show a loss on the year's working, being five more than in the previous year.

CHLORINE TREATMENT OF DRINKING WATER

In the issue of The Canadian Engineer for July 27th, 1911, an article was published with the above title. Mr. J. Race made certain comments and corrections on this article on page 203, in the issue of August 17. In a recent issue of the Sanitary Record of London, Eng., appeared the following letter, making other remarks on the same article, which was reproduced in the Record's columns in their Oct. 12th issue:

Sir,—My attention has been directed to an interesting, but in some respects misleading, article under the above title, which appeared in your issue of October 12th. In that article it is stated that when hypochlorite is used for sterilizing water, the residual water has an objectionable flavor, due to the calcium chloride formed by the de-oxidation of the hypochlorite. This is quite a mistake. The amount of chloride formed cannot exceed two parts in a million of water, or 0.14 grain per gallon. Now, very many excellent potable waters contain 20 to 30 times this amount. Many public supplies derived from the chalk contain 2 to 3 grains per gallon. As I have made thousands of experiments with this method of sterilizing, and devised all kinds of processes for removing the residual "flavor," I can say with certainty that this flavor is entirely due to the residual chlorine. Any process which is capable of removing this excess of chlorine removes the taste, and if a proper process is adopted, the water not only loses its flavor, but becomes as sweet, bright, and palatable as the purest of natural waters.

The best proof of this is the results obtained at the Reading Waterworks, where the water of the river Kenneth is treated by the De-chlor process, and when so treated is odorless, tasteless, bright, and pure. After the addition of chlorine, or chloride of lime, the water has a most objectionable taste, but after passing through the De-chlor filter the taste has disappeared. As the process has been in use for nearly a year, and the water supplied to the consumers during the whole of that period, there can be no doubt about its efficiency.

I have no interest whatever in this process, beyond that of the interested observer, and I can assert that it is far simpler and more efficient on the large scale than any other which I have been called upon to investigate. Any of your readers who are desirous of obtaining details can consult the Waterworks Engineer (Mr. Walker), whom, I am sure, would gladly give them any information they desire.—Yours faithfully, John C. Thresh, M.D., D.Sc.

Public Health Laboratory,
London Hospital, E., October 24.

FIREPROOFING.*

By Richard L. Humphrey of Philadelphia, and President of the National Association of Cement Users.

America has, as you all know, the proud distinction, if you wish to put it in that way, of having, as she has in many things, the greatest fire losses in the world. The losses in America are enormous, and each succeeding year does not seem to bring an appreciable decrease in them. Where the losses in Europe are reckoned in cents the capital losses in America are reckoned in dollars—nearly ten times the average loss of Europe. It would seem, therefore, that it was rather incongruous for America to come and talk to a country that is particularly low in fire losses on the subject of fireproofing.

* Abstract of paper read at General Meeting of the Concrete Institute, England, October 26th, 1911.

But I think if you bear with me a minute you will see that perhaps the very fact that we have such enormous losses in America has led us to study this subject of fireproofing or fire prevention, and it has been a necessity to find out ways and means to prevent this enormous annual destruction of building materials by fire.

While it is true you do not have the capital losses of two or three dollars annually, nevertheless there is no reason why you should have the capital losses at all, and the mere fact looking across the great pond you will find the losses are much greater in America than here is no reason why you should be self-satisfied and not strive to prevent the losses that you do have here.

We find in America that it is necessary to erect buildings of high fire resistance, and then it is necessary to provide a means of putting out conflagration of the contents. I find, in contrast, that in America we build, under our rather poor building laws that are promulgated generally, buildings of a low fire resistance, and we equip our fire departments with magnificent fire-fighting appliances, high-pressure water systems, and the country is subjected to a great annual tax for the maintenance of this expensive fire-fighting system.

The annual losses are not by any means represented by the annual destruction of property. In addition to the destruction of property and building materials, there is the annual tax that is necessary for the upkeep of the fire protection service, and then the additional tax that comes from the very high rates of insurance; so that year by year the total annual losses from fire, which I believe are entirely preventable, are represented by a great deal more than the two or three dollars per capita, which is merely the value of the property destroyed.

I think it is regrettable when you come to think of it that this property, and the lumber which goes into it, that is once destroyed is a permanent destruction, and we feel in America that where the question of the concentration of the resources is receiving so much careful attention it is of the utmost importance that we should study the conservation of our building materials; so that I think now generally throughout America there is a tendency to revise the building laws for the purpose of ensuring the erection of better structures. But of course it is impossible to make those laws in a large measure retrospective, and there must necessarily exist for many years to come buildings which at best can only be described as tinder boxes.

Of course, in America great conflagrations have occurred. The one in Chicago was perhaps only second to that in San Francisco, but in Boston in 1872 and Baltimore in 1904 conflagrations of great size, which destroyed property worth millions of dollars, occurred, but were only small in comparison with the large area of Chicago and San Francisco. In Baltimore the fire-fighting service from Philadelphia, New York, and Washington were practically powerless because in the extreme cold weather which prevailed at that time the water service was of little value. It is interesting to note that in the San Francisco fire it is estimated that the profits of twenty years were destroyed in a fire of three days' duration.

It frequently happens that the walls of a structure are standing after a fire, and people point to those walls as an evidence of the fact that the building has satisfactorily passed the conflagration. It often happens that the walls are of concrete, and after the fire are in good shape, and only require a renewal of the floors, doors and windows and roof to make a habitable dwelling.

It frequently happens that the floors and columns are fireproof, but the front walls are cast-iron, which are destroyed, or the walls of brick all fall down. One of the best examples in America of the behaviour of reinforced concrete in a serious conflagration was the buildings of the Guarantors' Trust Company of Baltimore, and load tests were made on those floors after the fire by the building department, and they were found to be amply safe under the ordinary building laws. In the destruction of the adjoining building opportunity was afforded for the construction of a modern building, and it became necessary to tear down the rebuilt structure because it did not fit in with tne new structure, otherwise it was in very good condition.

Stone is very largely used, not only in this country and America, but all over the world, as an ornamental material, and it is evident, I think, from the study of buildings where there have been fires of intense heat that the stone is almost entirely destroyed. It is almost impossible to replace the ornamental character without rebuilding the structure entirely, and the behavior of granite and hard sandstone in fire, which splinter and split, is ample evidence that the subject of natural building stones should be studied with a view to determining their resistance to fire. The United States Government have undertaken some studies of this kind and they have found that it makes a material difference as to how the stone is quarried in its fire resistance. They found that granite can be quarried so as to offer almost 100 per cent. greater resistance to fire in one direction than it does in the other direction; so that in the matter of ornamental building stones there is much to be learned in the manner in which the stone is quarried from the point of view of its fire resistance. Of course in a building of this kind the destruction cannot be estimated. The mere fact that the skeleton remains is not very much consolation, and when ornamental parts are also structural parts carrying the walls, then, of course, the construction seriously endangers the safety of the structure, and when granite columns form the interior columns of the construction, their destruction is a matter of serious concern. If stone is to be used as a structural member of a building, it must be fireproof just the same as a steel member shall be fireproof.

In nearly all the great conflagrations which I have visited—and I have visited most of them in America—it is a frequent sight to see buildings of steel which have not been properly fireproofed entirely destroyed, and it is evident, I think, that something must be done to protect that material, for while steel may have great strength at normal temperatures, it has little or no strength at high temperatures. Then, again, it frequently happens that the floor of a structure may be reasonably fireproof and constructed properly, but the supports of the floor are cast iron, or some equally bad material, and the failure of the column to support the floor causes a collapse.

It is a striking fact that architects and people in general in America regard burnt clay as an admirable fireproofing material; and I think in a large measure this opinion has been based on the fact that small pieces of burnt clay when placed in a fire and heated and thrown into water are not disintegrated. But the clay is not used in that way. It is used in the shape of a tile. In the process of manufacture it often happens that these tiles are cracked in the corners, and when a column which is fireproofed is subjected to the action of heat, as the unequal expansion of the outer face of the tile contrasted with the inner face against the steel causes an expansion which the thin web at the corner is unable to resist, and the tile and the web cracks. As a result, the tile is broken away from the column and the column is left to the action of the heat and collapses.

It often happens that in the construction of columns an attempt has been made to fireproof them by binding around the column perhaps a metal fabric and then plastering it. In the Fairmont Hotel about 100 columns fell as a result of this kind of fireproofing. It frequently happened that the floor settled as much as a foot. Now, you must bear in mind that there was no great fire in that building. The hotel had not been completed, and the only material there was the lumber that was used in the construction of the building, which was not a great amount, but the burning of this lumber was sufficient to develop enough heat to buckle the flimsily constructed columns, and in the destruction of such buildings one frequently sees the folly of those flimsy evasions of the law.

It is quite general in a fire that where terracotta tiles have been used the lower web, by reason of its expansion, has flaked off, and you see the floor area. Perhaps as much as 35 per cent. of the web failed so as to come off, while a larger per cent. perhaps are cracked so badly as to be able to be pulled off with the fingers. Now, in a case of that kind nothing can be done in the way of restoration except by entire reconstruction of the floor.

The floor, of course, is an important structure. If the column is reasonably fireproof it is necessary that the floor shall be fireproof. The suspended ceiling was found in the San Francisco and Baltimore fires to act as an excellent shield and greatly increased the fire resistance of the floor. Unfortunately in carrying out this idea it frequently happens that ordinary gypsum or plaster is used, and with a very flimsy anchor the gypsum loses its life at a very low temperature and the anchor is destroyed in heat and the ceiling falls.

It generally happens that the roof trusses of a building are never protected. The upper ceiling is rendered reasonably fireproof, but the steel trusses of the roof are not protected, and as a result it frequently happens that the roof becomes the entry for a fire from the outside. It is just as necessary to protect the steel work of the roof as it is any other part of a structure.

In most cities we find that there are buildings of large size that are reasonably fireproof. They are monumental in their construction, but they are surrounded by fire traps, and this is particularly true in our large cities in America, where we have buildings that are extremely high, and which, if they were properly protected, with metallic window frames and door frames and fire-glass windows, would probably act as a barrier, but with unprotected plain glass, and perhaps wooden frames, the destruction of the tinder boxes that surround them brings about the destruction of the contents of the buildings themselves.

It is not only necessary that the floors and columns of a building shall be properly protected against fire; it is also necessary that not only the interior but the outside shall be protected. It frequently happens that the windows are perhaps metal frames protected with terra-cotta or some similar fireproofing, and the destruction of those windows leads to an easy access for the flames to spread from floor to floor, and lead to the entire destruction of the building.

In some cases where metal doors and windows were used, and plain glass used in the window, the glass simply softened and fell down, and so, of course, the barrier was of little value. On the other hand, when the window is constructed with metal frames and wire glass windows of approved type, the glass often softens, but still stays in place and prevents the fire from gaining access to the building.

I believe personally that concrete is going to play a very important rôle in the question of fireproof construction of the future, and it was for this reason that I took for my subject to-night, in addressing this Institute, the subject of fireproofing, because I believe that the Concrete Institute of England and the concrete organizations of America have a very important responsibility and a very important task before them. We know that concrete is reasonably fireproof. We do not know much about its properties or the methods of the construction from the point of developing buildings of the highest fire resistance. It is a fact in America that in a report of the various concrete buildings that have been erected during the last five years the owners of 23 per cent. of the buildings reported that they carried no insurance on the buildings themselves, that they merely insured the contents.

Now, in a building of concrete, when properly constructed, there is a building of the highest fire resistance; but. unfortunately, there is a tendency to design the structural parts of a building without providing any fire protection. It is just as necessary to provide fire protection for the concrete member in the structure as it is for a steel member, a wooden member, or a stone member. There is no doubt that different aggregates have different rates of expansion, and that these different rates of expansion cause a proporionate destruction of the concrete.

THE CONTRACTOR'S VIEW OF CITY CONTRACTS AND SPECIFICATIONS.*

By C. A. Crane.†

The subject of this paper is one which has been often and thoroughly discussed for the last several years. A most admirable paper was presented before your society by Mr. John C. Wait some six years ago. The matter was also very exhaustively discussed before the American Society of Civil Engineers in a paper presented by Mr. William B. Bamford, in 1910, and "The Contractors' Point of View on Engineers' Contracts and Specifications" was the subject of a paper before the Association of Engineering Societies, presented in July, 1907, by Mr. James W. Rollins, jr., president of the contracting firm of Holbrook, Cabot & Rollins.

However, in spite of the discussion brought out by those papers and the almost unanimous agreement that contracts were too one-sided, no perceptible change for the better has occurred.

Every one of you engineers here to-night will agree with me that there are many unfair clauses in contracts you have been engaged upon, but individually, you may say, "I didn't prepare it—I had nothing to do with the specifications—why don't you make the kick to the man who drew it up?" And when we find the man who drew it up, he says, "These contract matters are up to the Corporation Counsel," or "They are regulated by charter or ordinance," and as to the specifications, unless they be for some extra large undertaking, the old ones are copied year after year because there has been no general demand to change them.

We are all agreed in one thing—none of us will ever live to see a perfect contract on city or any other public work. So long as the bidding on contracts is unrestricted, the contract must of necessity be drawn to protect the city, or the state or the government, from dishonest practices. No reputable contractor can object to this condition, nor will he deny its necessity, but what he does object to is, that those clauses which are inserted in the contract more for protec-

* Extracts from a paper presented before the Society of The Municipal Engineers of the City of New York, October 25, 1911.

† Secretary of the General Contractors Association, 21 Park Row, New York City.

tion than literal enforcement, are often applied to him regardless of good and substantial performance, in order to secure strict compliance with the specifications. I allude to the so-called "Club Clauses."

Mr. Rollins, in his paper just alluded to, says: "Every unnecessary or unfair clause in a specification has its part in limiting competition and in lowering the standard of honesty among contractors. A clause that may be used as a club can be avoided in one or two ways, either by not bidding on work governed by the clause or by using graft to insure that it shall be a dead letter."

An instance of one of these impossible requirements, or club clauses, is to be found in the contract for asphalt pavement in the provision for tests just prior to the expiration of the guarantee. The clause provides that if any portion of the pavement shall show a variation of more than ⅜-inch under a 4-ft. straight edge, such portion shall be immediately repaved by the contractor.

Is there a pavement in the country, let alone Greater New York, which can comply with so rigid a test after five years' usage? I very much doubt it, and at the same time I have never heard of any engineer who applies his 4-ft. rule to the entire surface of the street before issuing his certificate. Perhaps this clause was responsible for the report of an engineer in the Bureau of Highways not long ago who refused to certify that the work had been placed in acceptable condition because the pavement still showed waves of sufficient magnitude to make water hesitate! In making the statement that this impossible test is not resorted to, it should not be presumed that it has been avoided by payment of graft, as might be assumed from the foregoing quotation. It is simply because the requirement is so thoroughly ridiculous that it is hard to conceive of any engineer who would have the nerve to proceed towards its enforcement, or of any Borough President, or court which would sustain him if he should.

The contracts prepared by the Board of Water Supply for the Catskill Aqueduct are conceded by contractors to be as fair as any they have ever worked under. The specifications are explicit in defining every detail that enters into the construction, and just what the payment for each item includes. No expense has been spared in procuring the best engineering skill, and the advance information to bidders is presented in a most complete manner. Yet the clause disavowing responsibility for the estimate appears in the contract.

The contractor is told he must conduct his own investigations in the six weeks, at most, before submitting his bid, which of course he cannot do. He is bound to be guided by the information furnished by the engineers, and if it subsequently turns out to have been misleading, to a degree, entailing additional work and expense, such a contingency should be provided for in the contract.

Engineers who have spent months in taking borings, making subsurface examinations and preparing their estimates know how impossible it is for the contractor to verify this work before bidding, and they should be the first to endeavor to have this clause eliminated in order to allay a sometime suspicion that the low bidder obtained advance information which was withheld from his competitors, and that he got the job because of such exclusive information.

This clause was decided in the contractor's favor not long ago by the Connecticut courts. The portion of the opinion relating to the legal status of the estimated quantities was very clear. It stated that the representations in the advertisement and the notice as to quantities carried with them "the assertion of being made upon some basis of superior knowledge. Their purpose was to supply information to persons who were expected to act upon it in a business dealing with those who made them, and who were entitled to accept and act upon it as expressing what it purported to express, to wit, information having a basis in such superior knowledge." Elsewhere in the opinion the matter is explained in other words:

It is apparent that the facts involved in the statements and representations in question were such as not to be equally available to both parties, were not at hand or within the observation of the contractors, and involved investigations of conditions, study and computations for which expert technical knowledge was required, if not also a search of the minds and purposes of the members of the board. They were made by a party in a position to have, and who assumed to have, not only a superior knowledge, but also a knowledge which had a foundation in expert examination and study, and they were made for the purpose of being acted upon, and promptly acted upon.

If this be good law, it only requires a similar case in this state to forever knock out the irresponsible clause.

It is a confession of laziness or lack of faith in his ability for an engineer to insert the provision that if anything has been omitted from the plans or the specifications, which is required to satisfactorily complete the work, such omission shall be supplied by the contractor without extra compensation. Such a clause might also be urged as justification on a contractor's part for evading the specification in every possible particular, for as a man who had been up against this very clause once observed: "The contractor is justified in safeguarding his pocketbook if an engineer can insert such a clause simply to safeguard his reputation."

Then there is the clause vesting in the Chief Engineer indisputable power of interpretation of the contract and specifications, and judicial determination as to their execution. This clause presupposes that the engineer is a better lawyer than the courts, or at any rate, makes him paramount. While it is generally thought by contractors that the clause is illegal, it is still retained in many contracts for the simple reason that no satisfactory substitute has yet been discovered.

The methods of arbitration which have been tried have not thus far been as successful as anticipated either in point of economy or rapidity in settling disputes. One great fault with the system of arbitration generally adopted has been in the number of arbitrators appointed, and when two arbitrators fail to agree the case is presented before an umpire. It would seem to be the better way to appoint only one arbitrator and to leave his appointment to some impartial body of high standing, such as the American Society of Civil Engineers, and to stipulate a time limit in which each side must present its case.

Another universal clause is that providing that the work may be suspended, without compensation to the contractor other than an extension of the time equal to the period of suspension—and that he may not claim damages for any delays caused by the failure of the city to provide him with the right of way. Since a time limit is put on the contractor, and liquidated damages for delays beyond the stipulater time are deducted from his payment, the city should also agree upon liquidated damages which the contractor may recover for any delay caused by the city, for certainly time is as valuable to him as to the city.

This clause respecting suspension of the work has been altered in the new form of contract for highways and paving, recently adopted, the modification allowing the contractor such reasonable expenses as he was put to by the delay or suspension. It has not, however, been changed by any other departments, and the injustice is so palpable that the lead taken by the Board of Estimates Committee should be followed in all city contracts.

Another peculiar provision is that while the contractor must assume entire responsibility for the safe conduct of the work, and the methods of construction, the engineer reserves the right to approve or disapprove his plans. Before obtaining a contract on the Catskill Aqueduct, the contractor must give satisfactory evidence of his experience and ability to undertake the work, and if subsequently the engineers for the city insert their suggestions into his plans for doing the work, should not the city shoulder the responsibility in the event, say, of the failure of a temporary structure?

An objectionable clause in the sewer contracts is that giving the city the right to connect any sewer or drain with a sewer under construction, and holding the contractor for the maintenance and cleaning of the used portions until the completion of the entire work. This clause should specify that only the connection could be made, and that the sewer itself was not to be used, otherwise the contractor is entitled to damages, according to a recent Court of Appeals decision on this very clause.

Some engineers are too narrow to realize that a specification is a standard, and that an approximation to that standard fulfils the contract. The man who rejects masonry because the joints deviate a fraction from the specification, or piles because they are a half-inch under size at the butt, doesn't appreciate that he is standing in his own light—he never becomes a big engineer—he never has time to learn engineering—he is too busy inspecting.

In preparing this paper I asked the members of the Association to send in their suggestions and I received not only suggestions but many grievances. One member writes:

It might be as well to call the attention of the Municipal Engineers to the unfair conditions which often arise in city contracts due to the clause providing that for every day the contractor is delayed by the city he shall be entitled to one day's extension of time and nothing else. In the case of the New York Public Library, our contract amounted to over $3,000,000. We were prevented from completing our work because the city let another contract for work which had to be done before we could proceed with the remainder of ours.

As our contract was practically completed, our retained percentage amounting to $450,000, was held for a period of four months, but eventually an arrangement was made with the city whereby we were paid all but $12,000 of the retained percentage, and our bond for the execution of the contract was proportionately reduced. In addition to the loss of interest on $450,000 for four months, we were required to make good any defects in the work which might appear within a period of two years after the receipt of final payment.

Since we were unable to complete the engine room, due to the work of other contractors, until May of this year, we have not yet received the final payment of $12,000. The question now arises as to when the two years' guarantee shall begin. Should the date be when we receive the final payment of $12,000, now due, or should the date go back to April, 1910, when we had practically completed our contract and refrained from doing the small balance of work in the engine room, as an accommodation to the city? Upon such conditions you can appreciate that an extension of time of only one day for every day that the city delays the contractor is not adequate compensation for loss suffered.

Another letter in reference to this same public library. The contractor says:

There has been no friction or criticism of our work at any time, but in spite of the fact that the library has been opened to the public for about six months, and the city has had the use of all our work, we have not been able to get our final payment.

The principal difficulty seems to be in having the work properly inspected. Instead of having one thorough inspection, which should be sufficient, our work has been inspected by the architects, by the consulting engineers, by the Department of Water Supply, Gas and Electricity, by some other city departments, the name of which we do not recall, and finally, after all these inspections, still another one is now going on under another consulting engineer for the city. In each inspection trivial things were brought to our attention, which were corrected, but there does not seem to be any end to the inspections. It seems to us that this work could have been inspected as it progressed, and if any fault were to be found we should have been notified at that time instead of letting the present complex state of affairs arise. It also seems to us that there should be but one inspection, as thorough as the city could devise, and once it has been made and any changes recommended carried out, we should be paid.

These letters must strike a responsive chord in the mind of every contractor. The contract should stipulate a reasonable period after the completion when the final payment is to become due and allow interest if the payment is not made at the stipulated time. The interest clause for delayed payments is allowed in the Catskill Aqueduct contracts and has also been inserted in the recently adopted standard contracts for highway and paving work by the Committee of Engineers appointed by the Board of Estimate.

WINNIPEG POWER RATES.

On the basis recommended by the committee to the City Council the price per kilowatt hour to be charged householders for wire light is approximately 4½ cents net, as compared with 6¾ cents as charged by the Winnipeg Electric. The reduction from the present rate of the Company is therefore exactly 33 per cent. Over the prospectus rate, accepting the floor space basis as being a fair minimum charge, the advance is 11.1 per cent.

Without the actual measurements of a sufficiently large group of houses it is difficult to arrive at what the average floor space will be. In Toronto 200 plans submitted to the city architect were examined, and the result showed that the average floor space of houses with a given number of rooms was as shown in the following table. Taking the result referred to in Toronto as indicating what the average size of houses in Winnipeg is, together with the average amount of current used, determined likewise by actual experience in Toronto, the results show actual rates per kilowatt hour as already stated, and as given in tabular form as follows:

City and Company Rates Per Kilowatt Compared.

Rooms in house.	Floor space sq. ft.	Yearly consumption kilowatts	City price per kilo.	Co. price per kilo.
Four	650	144	4.95	8.33
Five	875	192	4.99	6.75
Six	1100	300	4.62	6.75
Seven	1350	360	4.52	6.75
Eight	1650	480	4.50	6.75
Nine	1850	540	4.50	6.75
Ten	2200	600	4.58	6.75
Eleven	2950	720	4.82	6.75
Twelve	3800	840	4.95	6.75

The prices per kilowatt as shown above are nett, the 10 per cent. discount being deducted in the calculations.

THE ECONOMIC ADMINISTRATION OF INDUSTRIAL ESTABLISHMENTS.*

By John Calder, M. Am. Soc. M. E.

(1) The Need of Greater Efficiency.—The files of the technical press and the proceedings of the engineering societies during the past ten years reflect the increasing attention which was given during that decade to the economic features of shop management.

That efficiency in manufacturing plants and their offices would become more and more a vital factor in such business was apparent from a brief consideration of the trade and traffic statistics of the United States Manufacturing Census as far back as 1900. These showed that proprietors expected to make on the average about 20% profit on their capital, however much it might have been watered.

The enormous dilution of capital in forming consolidations during the ensuing decade has rendered it impossible with unmodified organizations, except in the case of the monopolies, to keep up to the above profit. In many cases the margin has dropped to a very modest figure, and in some it has disappeared.

Forty years ago our decennial census showed that the capital required to produce a given quantity of manufactured goods was only 50% of the annual output. Twenty years later—in 1890—the capital required had risen to 70%, and in 1900, or within another decade, it had further risen to 75%.

In the latter year, $600,000,000 of the capital of the iron and steel industry, for example, produced products valued at $800,000,000, and at the present day the capital of the average manufacturing concern can be turned over only about once in nine months, instead of every six months, as formerly.

In the United Kingdom, where capital appears to be less watered, a turn over of capital twice a year appears to be below the average return, and Continental Europe also shows up favorably in comparison.

We need not dwell, by way of illustration, upon the statistical and economic facts of the transportation industry, which are well known to the present audience as a pressing problem of the day and one which the railroads, so far, have been invited to solve solely by internal economics.

The above condition of things is not as it should be, considering the great ability brought to bear upon American trade. There is no doubt that the real working capital at the disposal of our industrial managers—if known—would make a better showing for the United States, but it is worth while inquiring if we get full value from the present methods of expenditure. The returns from heavy capitalizations and enlarged plant facilities created during boom periods are not satisfying stockholders even in normal times, and are the first to be affected during a decline.

The function of organization in shop administration is not alone the important one of operating plants economically, but also to anticipate trade fluctuations, to measure up with care the prospective value and desirability of extensions, to check mere bigness of project and endeavor to make reasonable provision for a contracting expense of organization during a period of depression.

*Abstract of a paper read at a Joint Meeting of the Engineering Club and the Railroad Club of Altoona, Pa., Oct. 25, 1911.

(2) The Importance of the Organization.—Taking the desire for more economical business administration for granted, consider for a little, in the order of their importance, the various factors which will influence the result.

At the outset, we must reckon with the fact that the organization, not the system, is the primary consideration This is not the order of precedence prescribed by some professional systematizers, but any other is a mistake.

Every business worthy of the name must be provided with an organization, and no matter what particular system may be followed, it cannot attain economic distinction if it is not effectively organized.

The primary object of organization is to bring brainy men together for work and action. A wise organization seeks and encourages men of ambition. It believes that the ambitious man is not necessarily dangerous. It knows that success demands an aggregation of strong individualities, free to contribute their quota of wisdom, but loyally subordinating their individual preferences to the general policy once declared.

In order that its work may be well done and its action strong and forcible, the organization must move forward as a harmonious unit. No amount of clever scheming alone will secure this. Herein lies the task and the genius of the organizer of men, as distinguished from the mere systematizer of things. His work is much easier to talk about than to carry out, but it needs brief mention here.

When any business or industrial work becomes larger than its proprietors can take care of, they seek for assistance, and from that moment they and their delegate, the general manager, become organizers.

The organizer's success will depend not merely, or even chiefly, upon extended technical experience and close knowledge of the business, but upon his ability to select his assistants, to transfer his own work to them and to inspire those assistants with his own ideas, his own energy and his own ability.

Emerson says, "Every great business is but the lengthened shadow of one man," and he is right.

The modern administrator of industrial establishments is a manager of men rather than of things, and the human factor touches his business on all sides. I lay particular stress upon it at this stage, so that it may not get out of focus in an address which is chiefly devoted to an analysis of things.

An organization, therefore, cannot go into commission. It must have a strong, resourceful leader and a carefully selected, well-trained, loyal and enthusiastic staff. This will only come through intimate contact with a man, not a mere machine or inanimate system.

Having chosen men, frequently young men, for their record and potentialities, particularly for signs of executive ability, a not too plentiful quality, they should be expected to win solely upon their merits and to make the most of the business by making the most of themselves.

Unless the leader sees and plans for an opportunity for a useful career, not only for himself but for his staff, he cannot reach the highest success.

The cold-bloodedness of some of the modern schemes for exploiting the higher human energies is not only repelling—it is a fatal defect.

(3) The Systematizer.—Organization, though the greatest factor in business, implies co-ordination, or system, and not much can be accomplished without the aid of the latter.

Business methods and apparatus, particularly those of mechanical and transportation concerns, are being closely scrutinized and many proposals made for securing greater internal economy. At such a time it is well to bear constant-ly in mind that any system, however attractive and justifiable in some of its features, is, like the plant itself, worth no more than it can earn.

No manufacturer is in business as a subject for experimentation which may not point the way but merely warn others from following. All money and worry expended on system beyond the earning point is wasted.

An admitted experiment of measured duration and conclusive nature is one thing, but a shop revolution covering years of transition experiences is irretrievable and usually unsupportable.

Dead uniformity and absence of scope in a system for individual initiative and incentive are not necessarily factors in securing what are the sole justifications for special outlays on system, viz.: Absolute certainty of increased economy, accuracy and dispatch.

In concerns in which system is an expensive hobby and not an economical tool, all kinds of extravagances will creep in and will be justified by some philosophy which ignores common sense.

One of the claims brought before proprietors by some of the external practitioners of system is that it will not only render the efficiency of their business self-perpetuating—a most desirable end if attainable—but that it will also enable them to become, to a large extent, independent of their managers and higher executives.

This is a somewhat mischievous doctrine. No army of clerks, mechanically following planning instructions, however perfect, can take the place of the full use and recognition of able engineering administrators and shop assistants under any conceivable works system.

The human element in system, as well as in organization, is half of the problem and there is a tendency to too great rigidity in most of the shop systems offered for general application.

It is not a recommendation for any business system, imported from the outside, but rather the reverse, that it should insist upon absolute conformity to type in details without regard to the problem in hand and the great amount of experience already acquired from it.

Some of the most practical modifiers of shop management are fully alive to this, but there is a tendency amongst the less wise to vigorously wield the new broom.

It is the belief of the writer that the best type of shop system is evolved, not from the outside, but in the shop itself through careful analysis of its special conditions and requirements by the responsible administrator thoroughly in sympathy with and experienced in advanced practice.

A busy and prosperous administration can sometimes be helped by system advice from the outside. It should never be controlled by it. The most natural tendency of the outside adviser without responsibility for current product and profit is to stereotype the detail of his previous limited practice and dry up the springs of initiative and suggestion within the plant.

The best system for any particular shop is that which will co-ordinate all the efforts of a good organization and which will draw out and suitably reward the best effort of everyone concerned, not forgetting the employer. The most suitable management for so doing will never be exactly alike in any two cases, though the principles followed may be identical.

(4) The System of "Scientific Management."—It was to an already progressing and intensively developing shop practice that there was presented, ten years ago, "Scientific Management," a phrase to conjur with, which is much in the air at present.

It appeared at first with a more modest title, and made its appeal through the ordinary professional channels to the engineer. It was a worthy appeal, based upon a quite unusual amount of self-denying investigation; but it did not receive the immediate consideration it deserved. This was partly because the straw man which it set up and repeatedly and vigorously knocked down was merely a lay figure and not really representative, as alleged, of the best existing shop practice.

In the case of the more open-minded and thoughtful engineers, ready to learn from any source, the "science" of the movement was accepted with considerable reservation; and from the humanitarian point of view, the illustrations used by the gifted author of the system laid it open to not unjustifiable attack and to the complaint that though a deeply interesting experiment had been made, it did not justify the far-reaching generalizations based upon it.

In the ten years which have elapsed, professional efficiency engineers with no such experience as the able author of "Scientific Management" have multiplied somewhat more rapidly than the demand for this service would warrant. Quite recently "scientific management" itself has caught the fancy of the press and of the man in the street, and has been let loose through a popular propaganda upon an indiscriminating public. It will come back to its moorings after a while.

Actually, the particular system described and advocated by Mr. Fred W. Taylor has made relatively little progress, and, while economic administration of industrial establishments has been not a little quickened by its advent and discussion, the most of the general advance has been the result of causes operating before that event, and much of it has not been along the specific lines of such proposals in "Scientific Management" as are original with its author.

The fact of the matter is that Mr. Taylor's "Scientific Management" is a very big and difficult task, requiring professional ability of the highest order. Stripped of the data, apparatus and phraseology which have led careless readers to think of it as a new way of running machinery, of paying men, of avoiding labor trouble, of insuring dividends, etc., it is neither more nor less in its essence than a proposal to revolutionize our industrial life.

Viewed in that light, it is a most interesting and suggestive speculation which well repays close study by engineers. It presents itself to the shops in complete technical detail—a most expensive detail; and many businesses cannot contemplate the years of outlay involved before the returns promised should accrue. The author of the system is entirely frank on this aspect of the case; and system practitioners whose promises have a "get-rich-quick" flavor are certainly not installing the genuine "Scientific Management."

The writer believes thoroughly in the principles enunciated by Mr. Taylor, but is of the opinion that they are offered for application in a detailed system too complicated, rigid and unyielding for immediate application to every-day needs.

Shop management is an art rather than a science. It has to deal with too many unknown quantities and variables either to aspire to scientific rank or to adopt a fixed creed. Few individual businesses can afford the interference and expense involved in carrying out effectively the extensive scientific programme of the proposal under discussion.

By professional societies or national agencies, many shop problems still unsolved might possibly be greatly assisted without the risk of interfering with business; but the installation of the whole machinery of scientific management has been very seldom attempted.

Nevertheless, though committal of a shop to one rigid programme of outside origin in all its implications—and the control of the business, it must be remembered, is an invariable stipulation—is not, in the writer's opinion, desirable; there is plenty of scope for more systematic analysis and regulation of shop processes and expenditures. The business world, and engineers in particular, owe much at present and will owe more to the ability and devotion with which the author of "Scientific Management" has elaborated and advocated his particular combination of things old and new.

(5) The Proper Use of System.—There are several rules in regard to office and shop routine which the writer would recommend all managements to observe, irrespective of the class of work done.

(1) Have a well-considered system of doing things, definite and businesslike in all departments, not an imitation of something else, but one designed for your own case.

(2) See that a broad view of the subject is taken and provision made for properly dovetailing the various department systems.

(3) Make the connection clear to all employees by the use of a chart, such as Table 1 of this paper. Such a table is self-interpreting, and saves much explanation.

(4) Have as little system and as few forms as possible. Make them a means, not an end. There are many daily items of shop practice being perpetuated in expensive card systems to-day of which no use whatever is being made or is ever likely to be made.

(5) Do not treat the system as a fetich. It is a good servant; but a bad master. So much of it as is justifiable is merely organized common sense. Prune and pare your system until it gives the utmost economy and dispatch.

(6) Do not fail to note closely what your system costs, and if it is really paying its way. Very few experts can answer that question. With many it is purely a matter of faith.

(7) Be always on the outlook for improvements and suggestions from any responsible quarter and discriminating in adopting them.

The writer has spoken of useless records, with reference to data which need not be recorded at all in permanent form. Some other records are useless, because their form renders them so for the purpose of frequent and rapid reference. Still, other records are useless because they are inaccurate and unreliable.

The writer has heard it urged, in all seriousness, that detailed shop and cost data cannot be trusted; but this is simply a plea for slovenliness, which the users would not tolerate in their own technical spheres.

It is just as easy and cheap to collect—almost automatically in a good system—correct figures as it is to record inaccurate ones, and the man who knows exactly what he is accomplishing will always come out ahead of his competitor, who only thinks he knows.

The college boy more and more realizes nowadays that mathematical propositions are few and far between, and stiff commercial and shop problems many in the practical engineering field; but a good deal of dearly bought experience could be purchased more cheaply, we believe, if more of the money expended so freely in our universities was devoted to lectures by practical men on the real needs and practice of every-day manufacturing life.

It is a hopeful portent also that the manager and his assistants are no longer too busy to interest themselves in the details of factory accounts. These become, when properly presented, exceedingly interesting and suggestive documents, and the amount of modern system which we need bids fair to amply justify itself, particularly in lean years, by its results. The rest is dead weight and should go promptly overboard.

(6) The Variety of Management Problems.—Systems of management are necessarily as various in their details as the business conditions which have to be met. The simplest condition is that of a concern manufacturing a thoroughly standardized product which, under no circumstances, will they adopt or modify for special use. As a business policy, this may be carried too far, and the product may be out of date before the fact is realized.

In such a business, however, at one sweep many of the difficulties experienced by general engineering courses are disposed of, and attention can be concentrated on a limited number of definite problems, the satisfactory solution of which may be attained by gradual and experimental stages.

In plants in which standardization, a manufacturing basis of business and reasonable frequency of improved product are carried out to their fullest extent, the shops and executive staff have practically no necessary relation with the customer. They deliver the finished product to the warehouse of the sales organization, and the problems which their system should solve are purely internal. The lighter machinery manufacturers of standardized contrivances are embraced in this class.

At the other end of the scale we have the business in which a complication of agencies, some within and many outside the plant, must be skilfully tied up to each other by red tape—as little as possible, however, if they are to produce the desired results by a given time. These problems of successful management include such industries as shipbuilding, or mechanical operations dependent upon the simultaneous progress of civil engineering work at a distance; also work involving combinations of contracts.

In a class by themselves are problems like ship docking and repairing and locomotive overhauling, where the time during which a large investment is earning nothing is a governing consideration.

Between these extremes, namely, where cost is the determining factor on one hand and speed of completion on the other, there are all possible variations, no half dozen of which could be efficiently managed on precisely the same system.

(7) The Engineer and Shop Management.—The writer's own philosophy and practice in the economic administration of industrial establishments is the development of a quarter of a century's experience in the shops, ranging from the designing and engineering involved in the building of ships, locomotives, stationary engines and mill machinery to the manufacture of coal-handling plants, typewriters and adding machines.

These 25 years have been marked by a steady extension of the engineer's art, which now underlies a large part of our modern civilization. But the development has been intensive as well as extensive. Within the shop the managing engineer and his staff have advanced from more or less subordination to clerical controllers under the general system to no mean understanding of the once mysterious departments of accounting and costing.

In many cases, through the domination of the engineer in management, empirical rating and arbitrary labor in shop practice have become things of the past.

Most of the shop practices described in this paper are neither original with the writer nor with the modern advocates of shop systems. They are, in fact, and have long been, the commonplaces of shop management.

The minute sub-division of processes in manufactures was predicted and its advantages set forth in 1776 by Adam Smith, the Scotch philosopher at the University of Glasgow and the gifted author of "The Wealth of Nations." Sixty ly in mind that any system, however attractive and justifiable in some of its features, is, like the plant itself, worth no more than it can earn.

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In the case of the more open-minded and thoughtful engineers, ready to learn from any source, the "science" of the movement was accepted with considerable reservation; and from the humanitarian point of view, the illustrations used by the gifted author of the system laid it open to not unjustifiable attack and to the complaint that though a deeply interesting experiment had been made, it did not justify the far-reaching generalizations based upon it.

In the ten years which have elapsed, professional efficiency engineers with no such experience as the able author of "Scientific Management" have multiplied somewhat more rapidly than the demand for this service would warrant. Quite recently "scientific management" itself has caught the fancy of the press and of the man in the street, and has been let loose through a popular propaganda upon an indiscriminating public. It will come back to its moorings after a while.

Actually, the particular system described and advocated by Mr. Fred W. Taylor has made relatively little progress, and, while economic administration of industrial establishments has been not a little quickened by its advent and discussion, the most of the general advance has been the result of causes operating before that event, and much of it has not been along the specific lines of such proposals in "Scientific Management" as are original with its author.

The fact of the matter is that Mr. Taylor's "Scientific Management" is a very big and difficult task, requiring professional ability of the highest order. Stripped of the data, apparatus and phraseology which have led careless readers to think of it as a new way of running machinery, of paying men, of avoiding labor trouble, of insuring dividends, etc., it is neither more nor less in its essence than a proposal to revolutionize our industrial life.

Viewed in that light, it is a most interesting and suggestive speculation which well repays close study by engineers. It presents itself to the shops in complete technical detail—a most expensive detail; and many businesses cannot contemplate the years of outlay involved before the returns promised should accrue. The author of the system is entirely frank on this aspect of the case; and system practitioners whose promises have a "get-rich-quick" flavor are certainly not installing the genuine "Scientific Management."

The writer believes thoroughly in the principles enunciated by Mr. Taylor, but is of the opinion that they are offered for application in a detailed system too complicated, rigid and unyielding for immediate application to every-day needs.

Shop management is an art rather than a science. It has to deal with too many unknown quantities and variables either to aspire to scientific rank or to adopt a fixed creed. Few individual businesses can afford the interference and expense involved in carrying out effectively the extensive scientific programme of the proposal under discussion.

By professional societies or national agencies, many shop problems still unsolved might possibly be greatly assisted without the risk of interfering with business; but the installation of the whole machinery of scientific management has been very seldom attempted.

Nevertheless, though committal of a shop to one rigid programme of outside origin in all its implications—and the control of the business, it must be remembered, is an invariable stipulation—is not, in the writer's opinion, desirable; there is plenty of scope for more systematic analysis and regulation of shop processes and expenditures. The business world, and engineers in particular, owe much at present and will owe more to the ability and devotion with which the author of "Scientific Management" has elaborated and advocated his particular combination of things old and new.

(5) The Proper Use of System.—There are several rules in regard to office and shop routine which the writer would recommend all managements to observe, irrespective of the class of work done.

(1) Have a well-considered system of doing things, definite and businesslike in all departments, not an imitation of something else, but one designed for your own case.

(2) See that a broad view of the subject is taken and provision made for properly dovetailing the various department systems.

(3) Make the connection clear to all employees by the use of a chart, such as Table 1 of this paper. Such a table is self-interpreting, and saves much explanation.

(4) Have as little system and as few forms as possible. Make them a means, not an end. There are many daily items of shop practice being perpetuated in expensive card systems to-day of which no use whatever is being made or is ever likely to be made.

(5) Do not treat the system as a fetich. It is a good servant; but a bad master. So much of it as is justifiable is merely organized common sense. Prune and pare your system until it gives the utmost economy and dispatch.

(6) Do not fail to note closely what your system costs, and if it is really paying its way. Very few experts can answer that question. With many it is purely a matter of faith.

(7) Be always on the outlook for improvements and suggestions from any responsible quarter and discriminating in adopting them.

The writer has spoken of useless records, with reference to data which need not be recorded at all in permanent form. Some other records are useless, because their form renders them so for the purpose of frequent and rapid reference. Still, other records are useless because they are inaccurate and unreliable.

The writer has heard it urged, in all seriousness, that detailed shop and cost data cannot be trusted; but this is simply a plea for slovenliness, which the users would not tolerate in their own technical spheres.

It is just as easy and cheap to collect—almost automatically in a good system—correct figures as it is to record inaccurate ones, and the man who knows exactly what he is accomplishing will always come out ahead of his competitor, who only thinks he knows.

The college boy more and more realizes nowadays that mathematical propositions are few and far between, and stiff commercial and shop problems many in the practical engineering field; but a good deal of dearly bought experience could be purchased more cheaply, we believe, if more of the money expended so freely in our universities was devoted to lectures by practical men on the real needs and practice of every-day manufacturing life.

It is a hopeful portent also that the manager and his assistants are no longer too busy to interest themselves in the details of factory accounts. These become, when properly presented, exceedingly interesting and suggestive documents, and the amount of modern system which we need bids fair to amply justify itself, particularly in lean years, by its results. The rest is dead weight and should go promptly overboard.

(6) The Variety of Management Problems.—Systems of management are necessarily as various in their details as the business conditions which have to be met. The simplest condition is that of a concern manufacturing a thoroughly standardized product which, under no circumstances, will they adopt or modify for special use. As a business policy, this may be carried too far, and the product may be out of date before the fact is realized.

In such a business, however, at one sweep many of the difficulties experienced by general engineering courses are disposed of, and attention can be concentrated on a limited number of definite problems, the satisfactory solution of which may be attained by gradual and experimental stages.

In plants in which standardization, a manufacturing basis of business and reasonable frequency of improved product are carried out to their fullest extent, the shops and executive staff have practically no necessary relation with the customer. They deliver the finished product to the warehouse of the sales organization, and the problems which their system should solve are purely internal. The lighter machinery manufacturers of standardized contrivances are embraced in this class.

At the other end of the scale we have the business in which a complication of agencies, some within and many outside the plant, must be skilfully tied up to each other by red tape—as little as possible, however, if they are to produce the desired results by a given time. These problems of successful management include such industries as shipbuilding, or mechanical operations dependent upon the simultaneous progress of civil engineering work at a distance; also work involving combinations of contracts.

In a class by themselves are problems like ship docking and repairing and locomotive overhauling, where the time during which a large investment is earning nothing is a governing consideration.

Between these extremes, namely, where cost is the determining factor on one hand and speed of completion on the other, there are all possible variations, no half dozen of which could be efficiently managed on precisely the same system.

(7) The Engineer and Shop Management.—The writer's own philosophy and practice in the economic administration of industrial establishments is the development of a quarter of a century's experience in the shops, ranging from the designing and engineering involved in the building of ships, locomotives, stationary engines and mill machinery to the manufacture of coal-handling plants, typewriters and adding machines.

These 25 years have been marked by a steady extension of the engineer's art, which now underlies a large part of our modern civilization. But the development has been intensive as well as extensive. Within the shop the managing engineer and his staff have advanced from more or less subordination to clerical controllers under the general system to no mean understanding of the once mysterious departments of accounting and costing.

In many cases, through the domination of the engineer in management, empirical rating and arbitrary labor in shop practice have become things of the past.

Most of the shop practices described in this paper are neither original with the writer nor with the modern advocates of shop systems. They are, in fact, and have long been, the commonplaces of shop management.

The minute sub-division of processes in manufactures was predicted and its advantages set forth in 1776 by Adam Smith, the Scotch philosopher at the University of Glasgow and the gifted author of "The Wealth of Nations." Sixty years later, the principle was firmly established, and Charles Babbage, the noted English mathematician and mechanician, described in 1834, in his "Economy of Machines and Manufacturers," the minute division of labor in repetition work obtaining in his day in various industries which he illustrated. He also furnished a complete philosophy of the subject and examples of calculations as to the limits of reasonable investment in labor-saving machinery.

Industries, such as textiles, in which machinery reigned supreme at every stage, were most affected by the new principle which evolved quite naturally with the dawn of modern industrialism.

In our own day, practical political economy has been somewhat neglected by engineers, and three-quarters of a century after Babbage we find the division of labor by machines carried much farther than the divisions of handicraft, which he also advocated and described.

In many cases with us, the "trade" is still the economic unit instead of the "task," and this is particularly so in the metal manufacturing and building industries; not only so, but labor has shown no disposition to improve the "trades," many of which are notoriously wasteful of time and effort.

There can be little doubt in these days, when the high cost of living is a live topic, that economic necessity, if not inclination, will finally drive us to take up in all seriousness the conservation and intensive application of human energies in every department of activity, distributive as well as productive, and that new avenues of usefulness will open up for the production engineer.

It has not occurred to many engineers, as distinguished from the makers of purely machine-made products, to apply the intensive method of shop operation thoroughly to anything except very light and very simple repetition operations, and to not many even of these.

The second half of this paper is devoted to illustrating the principles already outlined in their application to a particular works problem. It is not in their novelty, but in their combination, intensive use and application with a measure of success to special and exacting business conditions that they perhaps merit some attention, and possibly convey, in no spirit of dogmatism, a few suggestions applicable, with suitable modifications, to other lines of work.

It may be emphasized here that the underlying practical motive of the system is not indiscriminate speeding at the expense of the workers, but the securing by co-operation of the economies obtainable through either anticipating or locating and removing all wasted time and ineffective or unnecessary effort and expense, whether clerical, manual or mechanical. It is directed towards enabling employee and capitalist alike, under the most favorable conditions to make the most of the opportunities of the working day, and in so doing a very large part of the usual burden is removed from the shoulders of the employee and placed upon the organization.

ELECTRO-MAGNETS FOR LIFTING PURPOSES.

At a meeting of the Sheffield Society of Engineers and Metallurgists, Mr. Edward C. Ibbotson, F.C.S., in the course of a lecture on the applications of electro-magnets to lifting purposes, said the strength of the magnets depended to a certain extent on the nature of the iron core. The late Dr. Snell was greatly interested in a series of experiments with different iron alloys that he tried in his endeavors to obtain with a minimum of weight the best electro-magnet for extracting pieces of steel from the eye. As iron was magnetic, i.e., could be affected by a magnet below the A critical temperature in the neighborhood of 750° C., it was possible to handle hot rails, etc., under the temperature of about 750° C., but the magnet should be properly designed for this work. Some special steels, such as manganese steels, and some high nickel steels under certain conditions, were non-magnetic at the ordinary temperature.

In drawing attention to the possibility of applying electro-magnets with advantage to every-day work, he illustrated by lantern slides the types of magnets, etc., that are in use. The first horse-shoe type was still used by some, but was now being superseded by the pot magnet, of which the Witton-Kramer magnet was a fine example. In the United States they made their magnets on truly American lines, viz., to work to their utmost limit of lifting capacity without taking much care as to the heating effect of the current on the coil. The current could be left on in the Witton-Kramer lifting magnets for an hour without injury to the coil which was mechanically protected by totally enclosing in a solid steel shell of special high permeability steel, and was made weatherproof by vacuum drying and impregnating under pressure with hot bitumen. It was then firmly fixed in the shell, and was entirely impervious to moisture. The current used was naturally direct current, and the consumption for large magnets, even where it had to be specially generated, was not a very serious cost. In many cases electro-magnets were a considerable labor-saving device.

Slides showing a number of magnets were thrown on the sheet, including a magnet lifting a seven-ton ingot; an electric locomotive job crane loading and unloading tinplate bars by means of a magnet, and a magnet suspended from an overhead crane transporting bundles of scrap wire. Numerous other types were given, showing the great adaptability of the method. By the kindness of the University authorities a demonstration was given in the metallurgical works laboratory immediately after the discussion.

PANAMA CANAL.

Canadians, as well as our neighbors in the United States, are looking forward with interest to the completion of the Panama Canal. The Pacific coast of Canada anticipates obtaining considerable benefit as the result of the building of this canal. It is thought that the waterway will be open for traffic in the early part of 1914 and formally opened in January, 1915, although President Taft recently predicted that it would be open in July, 1913. The project has a long and interesting history.

In 1825 a Frenchman obtained a franchise from New Granada, but failed to raise the necessary capital. In 1835 the United States sent an engineer to report on a canal project, but this came to nothing. In 1838 a concession was granted to France, but this concession lapsed. In 1848 a party of Americans secured a concession for a railroad across the Isthmus, and this road was opened for traffic in 1855, from Colon to Panama. Under this concession the Panama Railroad Company held exclusive right to construct a railroad or canal through certain territory, which gave it complete control of the Panama route. First-class fare for many years after the road was open was $25.00 gold, or about 50 cents per mile.

From 1853 to 1895, inclusive, this company paid dividends amounting to $37,800,000.00, or over 600 per cent. In

1869 the United States again took up the question of an Isthmian canal, and President Grant appointed a commission to investigate the matter. A treaty was entered into with the United States of Columbia in 1870, and as the Panama route was subject to the Panama Railroad Company's concession, the commission selected the Nicaragua route, and reported favorably upon it in 1876, but nothing was done, and France stepped in and remained in control until 1904.

Ferdinand de Lesseps formed a company in 1878, and secured a concession from the United States of Columbia. Surveys were made and the route from Colon to Panama was decided upon. The Panama Railroad was purchased for $18,000,000.00, and work was started on a sea-level canal; $240,000,000.00 was subscribed to the project and the time of completion was fixed as twelve years.

In 1887 it became impossible to secure more money and a lock canal was substituted for the sea level project, but at last the whole work stopped for lack of funds, $260,000,000.00 having been expended and 66,700,000 cubic yards of excavation having been removed.

In 1889 work was suspended and a receiver appointed. A new company was formed in 1894, and this company continued to do sufficient work to maintain its franchise, until in 1904 all of its rights were taken over by the United States. The total excavation by both French companies amounted to about 78,146,000 cubic yards.

The United States secured from the French company all of its franchise rights, the Panama Railroad, all the French surveys and maps, machinery, buildings, etc., etc., and paid therefor $40,000,000.00.

The United States has utilized 29,000,000 cubic yards of the French excavation in the present project, valued at $27,500,000.00. The Panama Railroad, for which the French paid $18,000,000.00, was valued at $7,000,000. A total of 76,000 acres of land was acquired. The French surveys, maps, and data were valued at $2,000,000.00. Up to the present, French machinery valued at $1,000,000.00, and French buildings, valued at about $2,000,000.00, are in use.

The United States made a treaty with the Republic of Panama and paid $10,000,000.00 for all rights conveyed, and agreed to pay $250,000.00 per annum, after the expiration of nine years from the date of the signing of the treaty. Under this treaty the United States guarantees the independence of the Republic of Panama and secures absolute control of the canal zone, a strip of land ten miles wide, through the centre of which the canal passes. This zone has an area of about 448 square miles. It is a perpetual lease to the United States for this territory with all governmental rights and privileges, but strictly it is not United States soil, for residents therein acquire no rights of United States citizenship. The cities of Panama and Colon, while within the five-mile limit which bounds the canal zone, from the centre line of the canal, are not included in the zone, and are considered Panamanian territory, although the United States has the right to regulate sanitary matters within their borders and preserve order with armed forces if they consider it necessary.

The canal will pass through the Isthmus from the south shore of Limon Bay, in a southeasterly direction, to Balboa near Panama, on the Pacific side. Its length from shore to shore will be 41½ miles, and from deep water in the Atlantic to deep water in the Pacific 50½ miles.

In entering the canal from the Atlantic, a ship will proceed from deep water in Limon Bay, a distance of seven miles, to the north end of Gatun Locks. It will be raised 85 feet through these locks, by three steps, and will then pass out of the locks into the Gatun Lake, which is formed by the Gatun Dam intercepting the Chagres River. The ship will pass through the lake and Culebra Cut to the Pedro Miguel Lock, on the Pacific side, a distance of about 32 miles, Culebra Cut itself being about nine (9) miles long. The ship will here be lowered 30 feet through Pedro Miguel Lock, by one step, and will then pass through Miraflores Lake, a distance of about two (2) miles, and enter Miraflores Locks, where it will be lowered 55 feet, at mean tide, by two steps, to the level of the Pacific Ocean. It will then proceed through the channel about eight (8) miles to deep water in the Pacific.

The channel throughout its entire length will have a minimum depth of 41 feet. The tidal variation on the Atlantic side does not exceed 2½ feet, while on the Pacific side it is about 21 feet. The time of passage for a ship through the canal is estimated to be from nine to ten hours, three of which will be spent in the locks.

BRITISH COLUMBIA.

More is being heard of the Peace River country, the last great hinterland. Surveyors report that it is a good grazing country, the chances for raising grain crops being as good as in many parts of the Northwest already cultivated. Exploration parties who were in the district during the past summer report that pioneers have found their way and have established homesteads. The British Columbia government is laying out the land within the borders of its territory so that settlers may go on to land that is surveyed.

Vancouver business men are taking action toward the construction of a line of railway direct from this city to the district soon to be developed, and more than one company would profit by the activity that will soon manifest itself there. Application will be made to the Dominion early in the year to incorporate the Vancouver and Peace River Railway Company, with all the necessary subsidiary powers. Amendment will be asked to the British Columbia and Alaska Railway Act, 1910, whereby it may run a line into the Peace River country. The Canadian Northern also may operate a route to reach the district, with the intention of ultimately extending the line across Northern British Columbia. The great northern interior has waited long for transportation facilities, but it was not until the Grank Trunk Pacific started construction that life was given. It is as much to the credit of the Grand Trunk Pacific as any one else that British Columbia's great undeveloped north is at last to have transportation.

The steamer is now being constructed at the mills of Canadian Western Lumber Company on the lower Fraser for the route between Fort George and Tete Jaune Cache. This will give Edmonton direct touch with the Fort George territory, for it will be an easy matter to transport goods by rail to the Cache and thence by steamer down the river. The present method by wagon from Ashcroft to Soda Creek is costly and slow.

The statement made by Mr. A. G. McCandless, president of the Vancouver Board of Trade, that the Vanderbilt interests have had representatives exploring the Peace River country, with the object of constructing a railway should conditions warrant, is interesting. The report, it is understood, is very satisfactory. Besides agricultural possibilities, great areas of coal, soft, bituminous and anthracite, were discovered. The rainfall is eighteen inches annually, copious at the season when it is most needed.

Metallurgical Comment

T. R. LOUDON, B.A.Sc.

Correspondence and Discussion Invited

ALUMINUM BRONZE.

Aluminum bronze is one of the best alloys and superior to manganese bronze provided it is properly cast. The reasons for this superiority are to be found in the following considerations: We can obtain a greater resistance and strength. Aluminum bronze is more homogeneous and less liable to take on crystalline structure in the interior of the casting. It has greater tenacity and with the same tensile strength is more pliable.

The difficulties in pouring the casting are of two kinds; namely, contraction and oxidation. Contraction is easily explained since all alloys possessing great strength contract considerably in pouring the casting. Aluminum bronze contracts more than manganese bronze. The oxidation when the slag forms is not greater, however, than in manganese bronze.

The best alloy for casting in sand molds is 90 per cent. copper and 10 per cent. aluminum. If greater tenacity is desirable, the percentage composition of aluminum can be reduced to 90 per cent. and the copper increased correspondingly to 91 per cent. A harder alloy can be obtained by increasing the aluminum to 11 per cent. For general machine parts, valves, bolts, etc., a 10 per cent. aluminum alloy is efficient. In making sheets of the alloy, the aluminum percentage is lowered so that the alloy becomes softer and can be rolled without trouble. The highest possible percentage in this connection is 8 per cent. The tenacity of aluminum bronze is greater than that of any other metal except steel.

A further characteristic of aluminum bronze is the color. The 5 per cent. alloy has the color of 18-carat gold, that of the 4 per cent. alloy is 14-carat gold color. The use of this alloy is very extensive and lately seamless tubes have been placed on the market made by the "Mannesmann" process.

To make castings with the 10 per cent. alloy, molds of green sand must be used. For such an alloy we use 9.9 lbs. copper and 1.1 lbs. aluminum. As very little aluminum is lost in the casting process, it is not necessary to use more than the amounts quoted. For very accurate work about 0.20 per cent. might be allowed.

The copper should be of the best quality and electrolytic copper is perhaps better than scrap copper. The aluminum should also be as pure as possible; commercial aluminum with 99 per cent. aluminum is best. The copper is melted in a graphite crucible without any aggregate except the wood charcoal which is used to cover up the metal thoroughly. This is very important as it prevents oxidation, which would take place during the melting process, if the metal was exposed. The same holds true for the melting of copper.

After all the copper has melted, which can be discovered by an iron or graphite stirring rod, the aluminum is added. This was first warmed for drying purposes and after adding and melting it rises to the surface. After all the aluminum has melted, and is floating on the surface, the mass is stirred with a graphite stirring rod. Aluminum bronze is immediately formed, as soon as it is heated to a white heat.

Scrap metal should be added to lower this heat and then the alloy may be poured. The aluminum bronze should not be used, however, in the first state after melting to make castings, as such castings will be full of flaws.

After the first metal has been poured into the form of bars, it must be remelted and then poured into molds, which will then give a perfect casting. The remelting is again done in crucibles, which must be carefully covered by wood charcoal.

Correct melting methods are necessary to obtain good castings. If the metal is heated too high, or if the fused metal is allowed to stand in the crucible for some time without pouring, gases are absorbed from the combustion product and these gases form blow-holes in the casings. The proper way is to keep the metal covered with charcoal till thoroughly fused and then pour it into the molds at the right temperature. It is important that the molds should be ready as soon as the metal is ready to be poured as any delay due to the molds not being ready or from other causes will result in poor castings.

Dry sand should not be used for a 10 per cent. alloy. It is too hard and does not allow the casting to contract without leaving cracks and flaws. Green sand is soft and has no bad influence on the contraction. The molds should not be rammed too solid and must be dry to a certain extent. A mold too tightly rammed prevents uniform contraction of the alloy, forms cracks, and causes spots and bubbles on the surface. Risers should be used in great numbers, as otherwise blow-outs will result.

The matter of slag is also of importance. To prevent the slag from entering into the casting with the metal itself, the alloy should be cast at as low a temperature as possible. A long gate will also be of value in this respect, and when this is used the slag will be retained in the gate and will not enter the casting. The metal should be poured in an even, quiet stream. Hurried and rapid pouring will result in the formation of slag.—Giesserei Zeitung.

THE HISTORY OF THE SHEFFIELD STEEL INDUSTRY.*

Professor J. O. Arnold.

The first beginnings of the steel industries of Sheffield, now so vast and in their metallurgical range so comprehensive, are to a great extent shrouded in historical darkness. This mystery may be traced to two chief causes. As to the first, the rude Saxons who founded on a puny scale these now gigantic industries were ignorant of the fact that the material development of modern civilization was to be largely brought about by the increasing efficiency of those weapons by means of which they slaughtered their kind in the fight for mere existence or the beasts of the forests and the field for bare sustenance; and beyond the question of survival there was to follow metallurgical progress an evolution of rapid means of transit of which they could have no conception.

The Paleolithic Age of the rudest forms of flint instruments is associated with the rudest form of man who, speaking in terms of geological time, had just emerged from the anthropoid apes. In the Neolithic Age, when the weapons of man, both for war and for domestic purposes (there are cynics who assert that the terms are synonymous), had assumed a higher finish and polish, there is evidence suggesting that man had reached a higher plane of development. Then came the Bronze Age, in which the flint hardness of the implements of the Stone Age was somewhat less efficiently reproduced on the edge of bronze weapons by plastic

*Abstracted from Times, Eng., Supplement.

strain or cold hammering. This falling off in a perhaps unnecessary degree of hardness was more than compensated for by the metallic plasticity which rendered the manufacture of the new weapons much easier and consequently made a much greater output possible.

Long afterwards came the Iron age. But who shall pretend to differentiate between the Iron and the Steel Ages? Roscoe and Schorlemmer quote from Pope's translation of Homer's Odyssey the following lines:—

And when as armours temper in the ford
The keen-edged pole-axe or the shining sword,

and they very truly comment, "These remarks evidently apply to steel, as wrought iron cannot be thus tempered." Nevertheless, the use of such steel (probably of the kind now called "natural" or "puddled steel") was confined to cutting implements and knights' armour, and was unknown for structural purposes. This age, this very modern age, has been until quite recently dominated by those metallurgical products known as cast and wrought irons. For instance, to go back only to the 19th century, one of the fine bridges spanning the Tyne at Newcastle was built of cast iron, whilst Telford's delicate yet majestic and even awe-inspiring structure over the Menai Straits is almost entirely constructed of wrought iron.

The second cause which shrouded in obscurity the beginnings of the marvellous development of Sheffield—now, so far as quality is concerned, the first steel centre in the world—is in the writer's opinion to be found in the fact that iron and steel workers have from the first had a tendency towards secrecy and consequently an aversion to any written records of the methods by which they wrought, carburized, and bent to their wills that stern metal called iron. It is worthy of note that this reticence is not confined to the white man. In Zululand the iron, "steely iron," or "puddled steel" workers, who have certainly for about two centuries made the assegai heads of the warlike Kaffirs of their race, including those for the legions of the mighty Chaka, have preserved as family secrets the methods by which in their peripatetic wanderings round the iron ore belt of Zululand they have made for their fellows the heads of their weapons of war. Consequently an unfortunate writer of fact has to rely upon tantalizingly brief references in the poets and the ecclesiastical records of the Middle Ages for data upon which to found more or less trustworthy metallurgical history in an article like the present.

No mention of the iron industry of Sheffield is made in Domesday Book, though at Bradfield (near Sheffield) Hunter has recorded that Roman coins were found in the midst of a mass of iron scoria. The records of the monks of Kirkstead Abbey show that at Kimberworth (near Sheffield) they had "pretty extensive" iron works—viz., two plants for smelting the ore and two for working the reduced iron into bars. These works were obviously making wrought iron from the somewhat manganiferous ferrous carbonate (or clay ironstone) containing about 0.25 per cent. of phosphorus which occurs in the district. The fuel would be charcoal, since the country round was amply wooded. At the present time in outcrops of ore to the east of Sheffield can still be seen hundreds of workings where the monks had dug down for ore until stopped by an influx of water.

Probably the earliest reference to Sheffield blades is made by Chaucer in "The Reve's Tale" (1386). It is therefore quite evident that even in those days of difficult communication the fame of Sheffield knives was well known in London. It seems reasonable to suppose that these blades were of fine steel. Indeed, in 1590 Peter Bales in the "Writing Schoolmaster" recommends Sheffield razors and penknives for cutting quill pens.

What, then, was the source from which the Sheffield steelworkers of the 14th century obtained their steel? Its reduction from local ore seems very unlikely, as such fine steel could hardly be made from phosphoric ores. It is significant in this connection that in 1442 the Royal assent was given to a petition asking authority to render the Don navigable by making tow-paths. The Don strikes the Humber at Goole, and this suggests that basis materials were being imported over sea. It is quite certain that in 1557 Spanish and Scandinavian irons were being imported into Sheffield. The following extract is from the accounts of the church burgesses of Sheffield for that year:—"Paid to Robert More for one stone and quarter of Danske Yron XXIId. Paid to ye same Robt. for X lib of Spanysche Yron XV." Hence "100" of Spanish iron cost 14s., whilst "100" of Danish (probably Swedish) iron cost 12s. In other words, the imported iron would in our present money cost about 146s. per cwt. The iron must therefore have been of surpassing quality, and such a costly basis metal would not have been imported if locally made irons could by any possibility have been employed for steel-making.

Hunter in his "Hallamshire" (p. 165) states that previous to 1615 Sheffield workmen could only make armour for the common soldiers. Knights' armour was always brought from abroad. That arch-antiquarian, Sir Walter Scott, had evidently come to the same conclusion. In "Ivanhoe," when he is describing the siege of Torquilstone (in the vicinity of Conisbro', near Sheffield), occur these words:—"Thrice did Locksley bend his shaft against De Bracy, and thrice did his arrow bound back from the knight's armour of proof." "Curse on thy Spanish steel coat," said Locksley; "had English smith forged it, these arrows had gone through an ass if it had been silk or sendal." There is little doubt that Scott located the opening scene of "Ivanhoe" near Woodhouse, about five miles to the eastward of Sheffield. Until quite recently wrought iron works known as the Rotherwood Iron Works were in operation at Woodhouse mill near the very site selected by Scott as a location for the homestead of Cedric the Saxon.

It is customary for writers who have made little or no research to assert that the reason why the steel industry originally developed round Sheffield was the proximity of beds of ore and of coal. But it has been already shown that the local ore was useless for the production of fine edged steel, and there is no record of coal having been employed until the time of Dud Dudley in the 17th century, three hundred years after Sheffield had firmly established her steel fame. Why, then, did the fine steel industry concentrate itself round what is now the premier city of Yorkshire? In the writer's mind there is no doubt that the main factor involved is the situation of the city itself. It lies at the confluence of four valleys, each having its small river—viz., the Sheaf, the Porter, the Loxley, and the Rivelin. All these rivulets fall into the river Don, which flows through the city. Each river has its own watershed, and runs throughout the year. Thus from Saxon times onward the steel artificers could get power for their tilt-hammers and grinding wheels at a nominal cost, and this fact constitutes the main reason why Sheffield hundreds of years ago became the centre of the cutting steel industry. A well-known Sheffield antiquarian, Mr. Thomas Winder, has produced convincing evidence, gathered by him from Domesday Book and other ancient documents, that the modern name Sheffield is the altered form of its original name "Escafeld," meaning "Field of Waters." In addition the carboniferous sandstone of the district still makes excellent grindstones, and refractory materials, such as ganister and fire-clay, are locally abundant.

It is certain that previous to the middle of the 17th century all Sheffield steel was of what may be termed plastic origin—that is to say, steel which had never been in a fluid condition. It would consist of two varieties differing really only in the amount of hammer work put upon them when in a red or yellowish plastic condition, and both made from a common material—viz., cemented, converted, or blister bar iron. The basis metals before carburization by charcoal in the cementation furnace would be the nearly pure irons wrought in the charcoal forges of Spain, Sweden, Styria, Flanders, and possibly Russia, and brought to Sheffield via Hull. The transit from Hull or Goole before the Don was navigable would be by packhorse. No wonder such irons cost about £145 per ton.

Probably each cutler had his own small cementing chest, because it was as late as 1759 that the Cutlers' Company erected on a large scale what would doubtless be a co-operative cementation furnace, in the chests of which many tons of iron could be converted at one operation. The nearly pure imported irons, however, all contained slag, consisting very largely of oxide of iron, the result being that when the carbon by what may be called carburization in the dry way permeated the iron the oxide of iron in the slag areas was reduced to metal with an evolution of carbonic oxide gas, which blew bubbles or blisters on the surfaces and in the interiors of the plastic bars. When the blister bar, which was very brittle, was heated and hammered into merchant sizes it was known as blister or tilted steel.

But for the highest quality of cutting implements, especially those required for clothiers' shears or for table blades, the blister bar was worked in a much more drastic fashion. Blister bar was broken into suitable lengths and each length was heated and somewhat hammered out to confer toughness on the brittle bar and to flatten down the blisters. Several bars were then piled and welded under a thin protective covering of suitable flux. The welded pile was next drawn down to a small rectangular faggot somewhat oblong in shape, so that in subsequent working the flats and edges of the welds could always be distinguished. The above faggot or small bloom was then worked into merchant sizes, and cutting articles made from it were branded with a rude representation of one pair of clothier's shears. Hence the name single shear steel.

For a still higher quality of steel a faggot of single shear steel was nicked, bent back upon itself, welded, and again worked down to the original size. Articles made from this steel, after it had been worked into merchant sizes, were branded with rude representations of two pairs of clothier's shears and were called double shear steel. Shear steel is the purest steel made, being practically iron and carbon. It is necessarily limited to relatively small sections; thus bars several inches in diameter sold as shear steel are sold under a false trade description. It is impossible to make such large round bars in shear steel.

Towards the middle of the 18th century Mr. Benjamin Huntsman, a Doncaster clock-maker, finding that worked blister bar was not sufficiently free from blister and weld lines for delicate clock springs, made experiments to find out a process which should give him a weldless steel; and in 1740 he discovered and established the crucible process at Attercliffe, Sheffield. Steel manufactured by this "fluid" method still further enhanced the reputation of Sheffield, and founded an industry which is now producing in Sheffield alone about 50,000 tons of cutting steels every year. About the middle of the 19th century this costly steel was used for structural steel, ranging from railway tires to heavy guns. But for the rails and armour of this period wrought iron was used, and there were consequently in the Sheffield district hundreds of puddling furnaces, which have now virtually disappeared.

In the early sixties the Bessemer, or to be quite just the Bessemer-Mushet, process firmly established in Sheffield those titanic operations known as the "heavy lines." For instance in less than 20 years Sheffield had become a great steel-rail manufacturing centre. Indeed, in 1879 Messrs. Brown, Bayley, and Dixon made in one week a world's record in rail rolling, turning out nearly 2,000 tons, a figure at which one now smiles. To-day only one firm, Messrs. Steel, Peach, and Tozer, make rails, the trade having on account of carriage charges perforce migrated to the coast so as to secure water carriage. To a great extent also the Bessemer process has been superseded by large Siemens-Martin furnaces on the regenerative principle—not because of any inherent fault in the method just named, but because the Siemens steel can be produced of even quality without that drastic scientific control necessary to obtain regular Bessemer results. This still important but waning method deserves a consideration based upon practical as well as scientific knowledge it has not received from authors of text-books, who probably have never made a heat of Bessemer steel in their lives.

Many text-books state that Mushet conceived the brilliant idea of adding spiegel or ferro-manganese, and so introducing carbon in such a way as to convert Bessemer's blown metal into steel. The facts are as follows:—Bessemer thought out and carried to a successful issue the grand conception of oxidizing the carbon and silicon in molten pig iron by a blast of air and so producing nearly pure iron. But his nearly pure iron contained several tenths per cent. of dissolved oxygen, which rendered his material so red-short as to be commercially worthless. Had carbon been able to remedy this fatal defect, half a ton of Swedish white iron would have put matters right. But such an addition to blown Bessemer metal would not render it forgeable. The patent of Mushet embodied a treatment of vast importance in steel metallurgy to-day. It was to add metallic manganese, which combined with the dissolved oxygen in the blown metal, rendering it insoluble, and so fluxing it into the slag. In the early days of the Bessemer process it was not realized that an excess of about 1 per cent. of manganese in the finished steel was necessary to get easily rolled ingots, and the slow process of the Bessemer method in its early days was largely due to the fact that an excess of only about 0.3 per cent. of manganese was left in the finished steel, a quantity far too small to cleanse the metal from dissolved oxygen. The carbon added by the ferro-manganese or spiegeleisen was necessary to produce steels of varying hardness, but it had little to do with rendering Bessemer's blown metal a commercial product. The honor of this achievement is due almost entirely to Mushet's manganese.

Another class of industry which has during the last quarter of a century enormously developed in Sheffield is the manufacture of steel castings in which the toughness brought about in worked steels by hammering, rolling, or pressing is secured by flame-annealing. For instance, the East Hecla Works of Messrs Hadfield, devoted mainly to this industry, cover 90 acres. Their relatively small Hecla Works, covering about four acres, are engaged chiefly in the manufacture of projectiles, of which they have supplied to various governments a number approaching 1½ millions. The manufacture of naval and military guns, carried out mainly by firms like Messrs. Vickers, Messrs. Firth, and Messrs. Cammell, Laird, has assumed enormous proportions. As to armour several firms have huge departments for the production of face-hardened armour plates. To give an idea of the vast concentration of the steel industry round Sheffield it may be stated that there are about 400 firms engaged in the manufacture or working of steel, or both.

To return to the cutting steels, say turning tools, the development in the efficiency of these agents of civilization is almost astounding. In 1740 the standard turning tool in iron and carbon steel contained as to-day about 1.25 per cent. of carbon. When hardened its turning efficiency was limited by the fact that its cutting hardness was thermally unstable, and the nose of the tool became soft and broke down with the heat of friction at a brown tempering heat, say 250 deg. C. This fact limited depth of cut, breadth of traverse, and speed of running within well defined limits.

Then about 1870 Robert Mushet, at the works of Messrs. Samuel Osborn and Co., put to a practical issue his discovery of tungsten steel. He found that tungsten so fortified the hardness of the plain carbon steel that the breaking-down temperature was raised perhaps 100 deg. C.; also that it was not necessary to quench such steel, but merely to cool it from, say, a yellow heat in a blast of air. Hence such steel was known as Mushet's self-hardening steel. Later, perhaps in the early eighties, Mushet still further fortified the thermal stability of the carbon hardness with relatively small quantities of chromium.

At the Paris Exhibition of 1900 Messrs. Taylor and White, of America, startled steel manufacturers by showing that a steel of the Mushet type might, under certain conditions, turn at a low red heat, say 550 deg. C. The steel makers of Sheffield were not slow to take this hint, and began that series of experiments which ultimately gave to the world modern high-speed steel, a material which has altered the whole trend of the possibilities of modern engineering output. The main features of this development from Mushet's original steel may be summarized as follows:—Much lower carbon, much higher tungsten and chromium, and the virtual abolition of silicon and manganese.

The final phase of this development has been the application as a fortifying item of the rare element vanadium. The influence of this element on steel was discovered in the manufacturing laboratories of the University of Sheffield in a series of researches extending from 1899 to 1902, and its application to high-speed steel by Sheffield makers followed a few years later. The net result of these collective Sheffield experiments between, say 1900 and 1910, was to produce a turning alloy with a thermal stability up to 650 deg. C., a distinct red heat, or in other words, an advance of 400 deg. C. over the plain carbon steel of 1740. The result, of course, is that cuts, traverses, and speeds which even in 1890 would have been dismissed as a madman's dream are now calmly accepted facts. To put this advance in another way, the 1740 turning tool would before breaking down remove 15 cubic inches of material, whilst, cœteris paribus, a second quality modern high-speed steel will remove, say, 215 cubic inches.

The latest application of science to steel making is to the melting and refining of steel by electrical heat as a substitute for the heat of external fuels, such as coke or coal gas, or the combustion of internal fuels such as carbon, silicon, manganese, and phosphorus. There are two main types of furnace—the arc and the induction. The latter must be regarded as a melting apparatus, the former as a refining furnace. There seems little doubt that electrical steel melting has come to stay, but to what extent it is not easy to predict. Its development has undoubtedly been retarded by the very able electrical engineers who have with consummate skill developed their methods, ignoring altogether the steel metallurgist's knowledge, and assuming that the problem was purely one of electrical energy converted into thermal energy. The electrical engineer has well achieved his part. The final verdict must be pronounced by the steel metallurgist. There are things in steel and iron metallurgy undreamed of in the philosophy of the electrical engineer.

It has been a common reproach that Sheffield was asleep, hide-bound, in this matter. No greater mistake was ever made. What are the facts? In Sheffield at the present moment there are (including one at the University Steel Works) three induction furnaces and four arc furnaces which are being worked on costly experimental lines, and this with electrical energy at, say, 0.6d. per unit. There is talk of making steel with 500 units per ton, but this is nonsense. That figure multiplied by two would be nearer the mark. The whole problem is still in the air, and the writer would ask electrical engineers to remember that Sheffield has a reputation for steel extending back into the centuries, and with this she cannot afford to trifle. In the writer's opinion the electrical method has a future before it, but it has yet to find its exact metallurgical level.

RAILWAY TIES OF REINFORCED CONCRETE AND ASBESTOS.

A new reinforced concrete tie is being tested on the Bavarian railways, which seems to combine the elasticity of wood with the durability of steel and concrete. This tie uses asbestos fibres soaked in water and saturated with pure cement as one of the elements. The mixture after complete saturation with water forms a soft, tenacious mass, which does not permit tamping or ramming as concrete does, but reaches two-thirds of the breaking strength of concrete. After setting, it can be drilled, nailed, and hammered like wood and retains its hold upon other materials better than wood. The concrete consists of one part cement, one part rubble, and two parts gravel sand. The asbestos is used only below the actual seat of the rails. The ties are 8 ft. 9 in. long, 8 in. wide, and 6 to 7 in. thick. Seven steel rods for the tensile zone reinforcement are imbedded below the rail seat, which is also of concrete, and the asbestos is placed on top of this. This lessens the cost of the tie, as the asbestos is rather expensive. A tie costs from six to seven shillings, and the weight is about three times that of the wooden tie (484 lb.). The setting of the cement and asbestos is much slower than that of concrete, and is accompanied by formation of heat. Hydrates of lime are formed in the process, as asbestos (calcium-magnesium silicate) has only a little silicic acid due to impurities. The excess of lime in the cement (25 per cent.) is also changed to hydrate of lime with formation of heat. Whether the ties will meet the requirements of the expected wear and tear is still a matter of doubt, as they have only been used for some nine months so far, although they have shown no defects within that time.

BACTERIA IN HOUSE DRAINS.

Dr. F. W. Andrewes, Local Government Board Medical Officer, dealing with experiments he had made in reference to the bacteria of sewer air, says: "While the experiments prove the possibility of the escape of sewage bacteria into the air of house drains, in the absence of an intercepting trap, we must not lose sight of the fact that the test organisms were present in the sewage to the number of hundreds of thousands, and in one case of at least 1,000,000 per cent. No one has ever suggested that pathogenic bacteria are present in sewage in numbers approaching this. In this country we may take the typhoid bacillus as the pathogenic organism most likely to be present in sewage. Yet no one has ever pretended to recover this bacillus from sewer air under natural conditions, and from sewage itself it has been recovered, if at all, only under exceptionally favorable circumstances and in very small numbers. These considerations must very largely discount any possible chance of harm arising from the escape of sewage bacteria into house drains even when no trap is present."

PERSONAL.

F. J. Robinson, Deputy Minister of Public Works, of Sask., has resigned to manage a financial concern.

Mr. J. P. Stockbridge, who represents C. A. Parsons & Co., of Newcastle-on-Tyne, builders of the Parsons turbine, is visiting various parts of Canada in the interests of this turbine which has such a wide application for driving generators, ventilating fans, etc. Mr. Stockbridge has recently been engaged in the installation of many large Parsons turbine plants in Australia. One of the principal results of his present visit to Canada has been the placing of the Canadian agency for these turbines with the Robb Engineering Co., Ltd., who will also manufacture certain parts.

COMING MEETINGS.

THE ENGINEERS' CLUB OF TORONTO.—Dec. 21, 96 King Street West Address on "Mountain Climbing," Major Charles H. Mitchell. Ladies night. Music and Refreshments. Secretary, R. B. Wolsey.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.—Jan. 24, 25, 26 1912. General meeting, 413 Dorchester St. West, Montreal. Prof. C. H. McLeod, Secretary.

THE CANADIAN FORESTRY ASSOCIATION.—February 6, 7 and 8, 1912. Annual Meeting, Ottawa. James Lawler, Secretary.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, C. H. Rust; Secretary, Professor C. H. McLeod.

QUEBEC BRANCH—
Chairman, P. E. Parent; Secretary, S. S. Oliver. Meetings held twice a month at Room 40, City Hall.

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain, Acting Secretary; E. A. James, 57 Adelaide Street East, Toronto. Meets last Thursday of the month at Engineers' Club.

MANITOBA BRANCH—
Secretary E. Brydone Jack. Meets every first and third Fridays of each month, October to April, in University of Manitoba, Winnipeg.

VANCOUVER BRANCH—
Chairman, Geo. H. Webster; Secretary, H. K. Dutcher, 319 Pender Street West, Vancouver. Meets in Engineering Department, University.

OTTAWA BRANCH—
Chairman, S. J. Chapleau, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

MUNICIPAL ASSOCIATIONS.

ONTARIO MUNICIPAL ASSOCIATION.—President, Chas. Hopewell, Mayor, Ottawa; Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

UNION OF ALBERTA MUNICIPALITIES.—President, H. H. Gaetz, Red Deer, Alta.; Secretary-Treasurer, John T. Hall, Medicine Hat, Alta.

THE UNION OF CANADIAN MUNICIPALITIES.—President, W. Sanford Evans, Mayor of Winnipeg; Hon. Secretary-Treasurer, W. D. Lighthall, K.C., Ex-Mayor of Westmount.

THE UNION OF NEW BRUNSWICK MUNICIPALITIES.—President, Councillor Siddall, Port Elgin; Hon. Secretary-Treasurer, J. W. McCready, City Clerk, Fredericton.

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. E. McMahon, Warden, King's Co., Kentville, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

UNION OF SASKATCHEWAN MUNICIPALITIES.—President, Mayor Bee, Lemberg; Secretary, Mr. Heal, Moose Jaw

CANADIAN TECHNICAL SOCIETIES.

ALBERTA ASSOCIATION OF ARCHITECTS.—President, G. M. Lang; Secretary, L. M. Gotch, Calgary, Alta.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, J. L. R. Parsons, Regina; Secretary-Treasurer, M. B. Weeks, Regina.

ASTRONOMICAL SOCIETY OF SASKATCHEWAN.—President, N. McMurchy; Secretary, Mr. McClung, Regina.

BRITISH COLUMBIA LAND SURVEYORS' ASSOCIATION.—President, W. S. Drewry, Nelson, B.C.; Secretary-Treasurer, S. A. Roberts, Victoria, B.C.

BUILDERS, CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary Treasurer, J. H. Lauer, Montreal, Que.

CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.—President, Charles Kelly, Chatham, Ont.; Secretary, W. A. Crockett, Mount Hamilton, Ont.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—President, Peter Gillespie, Toronto, Ont.; Secretary-Treasurer, Wm. Snaith, 57 Adelaide Street, Toronto, Ont.

CANADIAN CLAY PRODUCTS' MANUFACTURERS' ASSOCIATION.—President, W. McCredie; Secretary-Treasurer, D. O. McKinnon, Toronto.

CANADIAN ELECTRICAL ASSOCIATION.—President, N. W. Ryerson, Niagara Falls; Secretary, T. S. Young, Canadian Electrical News, Toronto.

CANADIAN FORESTRY ASSOCIATION.—President, Thomas Southworth, Toronto; Secretary, James Lawler, Canadian Building, Ottawa.

CANADIAN GAS ASSOCIATION.—President, Arthur Hewitt, General Manager Consumers' Gas Company, Toronto; J. Keillor, Secretary-Treasurer, Hamilton, Ont.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—President, W. Doan, M.D., Harrietsville, Ont.; Secretary-Treasurer, Francis Dagger, 21 Richmond Street West, Toronto.

CANADIAN MINING INSTITUTE.—Windsor Hotel, Montreal. President, Dr. Frank D. Adams, McGill University, Montreal; Secretary, H. Mortimer-Lamb, Windsor Hotel, Montreal.

CANADIAN PEAT SOCIETY.—President, J. McWilliam, M.D., London, Ont.; Secretary-Treasurer, Arthur J. Forward, B.A., Castle Building, Ottawa, Ont.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—President, T. A. Starkey, M.B., D.P.H., Montreal. Secretary, F. C. Douglas, M.D., D.P.H., 51 Park Avenue, Montreal.

CANADIAN RAILWAY CLUB.—President, H. H. Vaughan; Secretary, James Powell, P.O. Box 7, St. Lambert, near Montreal, P.Q.

CANADIAN STREET RAILWAY ASSOCIATION.—President, D. McDonald, Manager, Montreal Street Railway; Secretary, Acton Burrows, 70 Bond Street, Toronto.

CANADIAN SOCIETY OF FOREST ENGINEERS.—President, Dr. Fernow, Toronto; Secretary, F. W. H. Jacombe, Department of the Interior, Ottawa.

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto, President, G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July, August.

DOMINION LAND SURVEYORS.—President, Thos. Fawcett, Niagara Falls; Secretary-Treasurer, A. W. Ashton, Ottawa.

EDMONTON ENGINEERING SOCIETY.—President, J. Chalmers; Secretary, B. F. Mitchell, City Engineer's Office, Edmonton, Alberta.

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, W. B. McPherson; Corresponding Secretary, A. McQueen.

ENGINEERS' CLUB OF MONTREAL.—Secretary, C. M. Strange, 9 Beaver Hall Square, Montreal.

ENGINEERS' CLUB OF TORONTO.—96 King Street West. President, Killaly Gamble; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

INSTITUTION OF MINING AND METALLURGY.—President, Edgar Taylor; Secretary, C. McDermid, London, England. Canadian Members of Council:—Prof. F. D. Adams, J. B. Porter, H. E. T. Haultain, and W. H. Miller, and Messrs. W. H. Trewartha-James and J. B. Tyrrell.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—Secretary, R. C. Harris, City Hall, Toronto.

MANITOBA LAND SURVEYORS.—President, George McPhillips; Secretary-Treasurer, C. G. Chataway, Winnipeg, Man.

NOVA SCOTIA MINING SOCIETY.—President, T. J. Brown, Sydney Mines, C.B.; Secretary, A. A. Hayward.

NOVA SCOTIA SOCIETY OF ENGINEERS, HALIFAX.—President, J. N. MacKenzie; Secretary, J. Lorn Allan, Dartmouth, N.S.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, W. H. Pugsley, Richmond Hill, Ont.; Secretary, J. E. Farewell, Whitby.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, J. Whitson; Secretary, Killaly Gamble, 703 Temple Building, Toronto.

THE PEAT ASSOCIATION OF CANADA.—Secretary, Wm. J. W. Booth, New Drawer, 2263, Main P.O., Montreal.

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Secretary J. E. Ganier, No. 5, Beaver Hall Square, Montreal.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, F. S. Baker, F.R.I.B.A., Toronto, Ont.; Hon. Secretary, Alcide Chausse, No. 5 Beaver Hall Square, Montreal, Que.

ROYAL ASTRONOMICAL SOCIETY.—President, Prof. Alfred T. de Lury, Toronto; Secretary, J. R. Collins, Toronto.

SOCIETY OF CHEMICAL INDUSTRY.—Dr. A. McGill, Ottawa, President; Alfred Burton, Toronto, Secretary.

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, J. P. McRae; Secretary, H. F. Cole.

WESTERN CANADA IRRIGATION ASSOCIATION.—President, Wm. Pierce, Calgary; Secretary-Treasurer, John T. Hall, Brandon, Man.

WESTERN CANADA RAILWAY CLUB.—President, Grant Hall; Secretary, W. H. Rosevear, 199 Chestnut Street, Winnipeg, Man. Second Monday, except June, July and August at Winnipeg.