sults with automatic accuracy, verging on the supernatural. It is surprising to what an extent varying shades of this conception prevail, and as a result, there is an absolute lack of appreciation of the imagination, study, and continual process of balance and compromise to meet and overcome the obstacles of even the most simple engineering problem. The regrettable truth of this condition is brought home, in the fact that engineers are very often dependent for the practice of their profession upon the decisions of persons holding this view, who give the preference to the obvious "rule of thumb" engineer, with his "exact" results, over the engineer with sufficient vision and engineering conscience to qualify the limitations on which his results depend.

This idea may be accounted for, since the engineer is distinct from other professional men, as the lawyer, doctor, etc., in that he deals with forces and material things, as distinguished from human beings. In the popular sense, the latter require analysis, whereas, in dealing with concrete things, the engineer manipulates them by established formulas, requiring little else than a college diploma to operate, from the layman's viewpoint.

The question then, might be more aptly put, "Do the mass of people think?" with the inevitable answer, "Some do and some don't. The reply would be equally applicable to such a question relating to "students," "engineers," etc., the percentages pro and con varying within the limitation of such experiments as the trained psychologist might devise. In justice to engineers, therefore, we must recall that in the so-called intelligence tests (which, though open to question when applied to individuals, have been valuable in rating groups), the scores made by engineers, as a class, have paid high tribute to their mental discipline.

Referring to Mr. Van Auken's remedy for the "thoughtlessness" of some engineers with a quantitative recommendation for "a minimum requirement for remaining in service" of the annual consumption of "four technical books," "one weekly," and the membership in "one association," it is difficult to see what could be gained by such a procedure. As a suggestion from chief to assistant, the items are invaluable, and the employer will in many cases find himself anticipated by the wide-awake subordinate engineer, but as a "requirement to remain in service," the idea smacks strongly of that type of engineering thought best described as "rule of thmub," which, if carried to extremes, would justify the conception of the employed engineer as a "slide rule mechanic."

That there should be such a condition as that of "an employee sure of a steady promotion without regard to his fitness," is unfortunate, but it would not be ameliorated in the slightest degree by any such "requirement." History and many bloody wars have demonstrated the fallacy of attempting to stimulate thought by anything resembling legislation or compulsion. Under such a theory of technical literature dictatorship in any organization, the engineer would be still more open to the query, "Do engineers think?" with the logical reply, "No, they let their employers do it for them." Carried further, it is not difficult to imagine the subordinate "boning" at the last moment for his quarterly report, a picture reminiscent of student days.

In conclusion, I do not believe that engineers are relatively low in thinking capacity in the discharge of their duties, nor do I believe that either chief or assistant will subscribe to Mr. Van Auken's "minimum requirement" as a remedy for those who are. A real field of effort, however, is to be found in educating the general public to an understanding of the problems confronting engineers in their ordinary work. This might be done by the publication of a series of syndicated articles in the daily press under the auspices of an engineering society; the articles to be of an elementary scientific nature describing the properties and variations of materials, their application, and simple, non-technical outlines of the problems and methods of solution attendant upon engineering features. Such reading matter would be an eye-opener to "Constant Reader" as to the nature of the training and preparation necessary to accomplish such work. The interest of the reading public would instill in the young engineer a pride for his chosen calling, and be a constant spur to him to stay "fit" for the sake of himself and of his professional associates.

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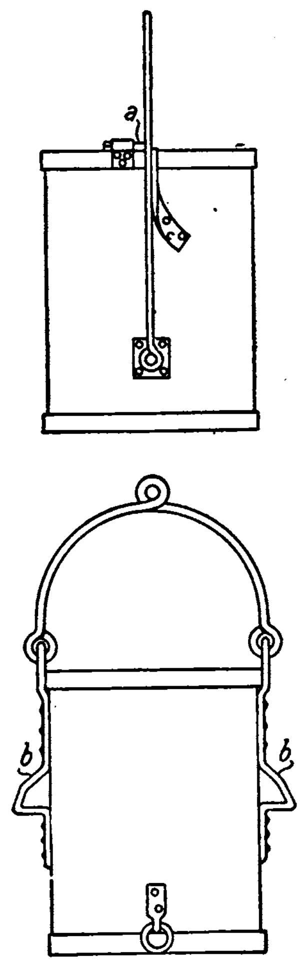
Buckets for Shaft Sinking

The type of bucket shown in the upper part of the illustration commonly used in shaft sinking, is a source of danger, according to a recently issued bulletin of the U. S. Bureau of Mines on "Safe Mechanical Equipment for Use in Shaft Sinking." Such a bucket is suspended from a bail, which is attached to the bucket below its center of gravity by trunnions or pivots, and is prevented from overturning while being hoisted by latches on the side of the bucket. Should the latches become bent or be jarred loose by continued use, or should the bucket catch during hoisting and the latches bend enough to clear the bail, the bucket will overturn and its contents will drop on the men working at the bottom of the shaft.



Above, Common Type of Bucket; Below, Type of Bucket Suggested; a, Latch on Each Side to Hold Bail Upright; b, Lugs.

A much safer bucket, states the bulletin, is one that has the bail so pivoted at or near the top that it will retain its upright position by gravity. Such a bucket may be emptied into a dump chute built into the head-frame by means of a "bull chain" hooked into the ring at the bottom of the bucket and so arranged that, as the weight of the bucket is transferred from the hoisting rope to the bull chain, the bucket is carried from its position over the shaft to one over the dump chute and then overturned. The bucket may also be lowered on a dumping truck which has slotted posts to support the bucket, with the slots holding the trunnions, and may be kept upright by a suitable latch while the truck is being pushed out to the dump. Either method of dumping requires little more time and effort than dumping by the ordinary method, and is much safer.

Notes on Operation of Electrified Line of C., M. & St. P. Ry.

Some interesting information on the operation of the electrified main line of Chicago, Milwaukee & St. Paul Ry. was given by Mr. A. W. Baker of the engineering department of the railway in a paper presented last April before the Minnesota Section and Student Branch of the American Institute of Electrical Engineers. The notes following are abstracted from the paper:

The electrification of the 443 miles of main line of the Chicago, Milwaukee & St. Paul Ry., from Harlowton, Mont., to Avery, Idaho, and 209 miles from Othello, Wash., to Seattle and Tacoma, makes this the longest and one of the most important electrifications of main line railroad in existence. The conditions on the 443 miles of the Missoula and Rocky Mountain divisions are especially severe. Grades run as high as 2% for a distance of 21 miles and 1% for 49 miles. Curves are often as sharp as 10 degrees. Tunnels are frequent—there being 36 in these two adjacent divisions. Weather conditions are extreme, including heavy snows and temperatures often reaching 40° F. below zero. The temperature conditions on the Coast division are not so bad but the grades run as high as 2.2% for 17 miles.

Why the Line Was Electrified.—The reason for electrifying was to overcome the difficulties encountered in the operation of steam locomotives under the above conditions. The chief difficulties were the inability of steam locomotives to haul heavy trains over the steep grades with sufficient speed to keep the track properly open for traffic in the opposite direction. Cold weather greatly aggravated this condition and tunnel operation was unsatisfactory; also the strain on air brake equipment going down steep grades required operation at slow speeds.

Characteristics of Electric Locomotives.—The chief characteristics of electric locomotives that enable them to meet the conditions of traffic on this line are as follows:

(1) High overload capacity as compared to no overload capacity of the steam locomotives.

(2) Greater power rating for same weight due to receiving energy from a source of ample power.

(3) Ability to return energy to the line by regeneration, thus regulating the speed on down grade and keeping the air brakes for emergency and full stop use.

The first characteristic often enables one electric to do the work of two equally powerful steam locomotives in pulling a train over a section of track requiring two steam locomotives for a short time. The greater power rating means that an electric locomotive having the same weight as a steam locomotive may be designed to exert its tractive effort at a much higher speed, or to haul a greater trailing load at the same speed. Regeneration saves brake shoes and wheel tires, increases safe operating speeds down grade, and chalks up a credit in generated power amounting for these divisions to about 12% of the total energy used.

The 443 miles of line is supplied with power by eight connections to the Montana Power Company's 100,000 volt, 60 cycle, three-phase lines. The railroad company has its own high tension line along the railroad for tying in and supply power to 14 sub-stations of 59,500 K. W. total capacity where the energy is converted by motor generator sets to 3,000 volts d. c. Electric service was started in December, 1915, and since early in 1917 full electric operation has been in use.

The first electric equipment consisted of 30 freight and 12 passenger locomotives of 288 tons weight, built by the General Electric Company. The passenger locomotives had a lower gear ratio and carried oil burning boilers for heating the coaches. These have since been re-geared for freight service and superseded by 10 specially designed 283-ton Baldwin-Westinghouse locomotives. Four 70-ton switchers are also in service.

The energy for the coast division is purchased from the Washington Water Power and the Puget Sound Traction, Light and Power Companies. There are eight sub-stations of 28,000 K. W. total installed capacity. Sixteen freight locomotives are now in service on this division leaving 26 for the other installation. The passenger traffic is handled by five bipolar gearless General Electric locomotives specially built for heavy passenger service and weighing 260 tons each. Full electrical operation has been used here since March, 1920.

Comparison of Electric Locomotives.—A comparison table of data on the electric locomotives follows:

Class	Freight	Passenger	Passenger	Switch
Builder	G. E. Co.	G. E. Co.	W. E. & M. Co.	G. E. Co.
Type of drive	Twin gear	Gearless	Full spring	Solid gear
Number	42	5	10	4
Wheel arrangement	44-4-4-44	24-8-8-42	462-264	4-4
Length	112 ft.	76 ft.	79 ft. 10 in.	41 ft. 5 in.
Weight, tons	288	260	283	70
Weight on drivers	225	229	184	70
Diameter of drivers	52 in.	44 in.	68 in.	40 in.
Number of driving motors	8	12	6 (twin)	4
Continuous rating	3,000 hp.	3,200 hp.	3,400 hp.	475 hp.
Tractive effort, tons	35.35	21	24.5	7
Speed, m. p. h.	15.9	28.4	26	12.8
One hour rating	3,440 hp.	3,500 hp.	4,200 hp.	670 hp.
Tractive effort, tons	42.25	24.25	33	11.2
Speed, m. p. h.	15.25	27.1	23.8	11.2
Tractive effort, starting	67.5	61.75	55	21
Tractive coef., starting	30%	25%	30%	30%

The freight locomotives haul a 2,500 ton trailing load up a 1% grade at 16 m. p. h. On 2% grades the load at first limited to 1,250 tons but has been increased to 1,400 tons. The passenger locomotives will haul a twelve car train weighing 960 tons up a 2% grade at 25 m. p. h. and will exceed 65 m. p. h. on tangent track. Field control is used in connection with motor arrangement to secure more running speeds.

Cost of Electrification.—The cost of the electrification is important from a financial standpoint although in this case it was small in comparison to the cost of building another track for steam operation.

The double 4/0 trolley line cost $8,390 per mile, transmission line $2,360, sub-stations, $6,030, and other costs brought the total up to $17,579 per mile not including locomotives. The latter cost $122,500 each and $37,700 for the switching type. The cost of the Coast division electrification in 1918-19 ran about 50% higher.

Maintenance costs on the locomotives were 8.21 ct. per locomotive-mile in 1916, 9.62 cts. in 1917, and 10.87 cts. in 1918.

The traffic data for 1918 shows a combined freight and passenger movement with 33.2 watt-hours per ton-mile. Without regeneration of about 14% this would be 38.6 watt-hours per ton-mile.

The entire electrical demand is under the control of a load dispatcher who can reduce the sub-station voltage and thus lower the train input by reducing the speed. This is done at times in order to keep the maximum demand for power down to a contract value. This gives a load factor of about 53%.

Electric Locomotive Performance.—The performance of the electric locomotives has been very satisfactory. Minor defects have been corrected as they developed. With steam operation freight locomotives made an average distance of 80 miles a day and passenger locomotives 100 to 110 miles with a maximum of 250 miles per day. Under electric operation the freight locomotives regularly make 220 miles and the passenger locomotives 440 miles per day. Steam divisions have been converted into two electrical divisions, with much less repair and maintenance work. Short inspections are made at division points and complete inspections every 5,000 miles. The maximum performance of a passenger locomotive was 12,000 miles in a month. On one who is familiar with steam operation these figures will speak loudly in favor of electric locomotives.

Other advantages that may be briefly mentioned. In cold weather the electrics are even more powerful than in summer and have been found able to buck the snow drifts with apparent ease. They often make up two hours of time lost on the adjacent steam divisions. They pull without seeming effort due to the absence of the puffing exhaust, and their power is limited mainly by the strength of the draw bars in the front cars. They effect a saving of about 300,000 tons of coal and 4,000,000 gallons of oil per year. There is no stopping for coal and water and the total ton-miles of traffic is about 10% less due to the absence of company coal, the empty coal cars and engine tenders.

The electric locomotives have greatly increased the traffic capacity of the road and have practically eliminated the mountain grades.

Light, Compact Double Drum Turbinair Hoist for Use in Tunneling and Other Work

A double drum turbinair hoist designed especially for hauling rock or ore scrapers, either on the surface in contract work or underground in tunneling or mining, has been brought out by the Sullivan Machinery Co., Chicago. In this hoist, the turbinair motor, in its casing, is supported on a central standard with a broad frame or foot, and supplies power to the two hoisting drums, each 10¾ in. in diameter by 5⅛ in. face, which enclose the motor. A driving pinion at each end of the motor casing engaged an internal gear in each drum shell. Air is admitted at a central inlet port. The two drums are controlled independently by friction clutches and band brakes. The clutches are at the outer ends of the drum and the brake bands and handles at the inner ends. By this method either drum may be operated separately or both may be thrown into gear at the same time. In "slushing" work the live or hauling rope is attached to one drum and the tail rope or return rope to the other drum. By means of a suitably placed snatch-block or arrangement of sheaves, the tail rope is paid off the second drum as the load comes in on the first and when the scraper has been dumped, the process is reversed, the clutch being thrown out on the live rope drum, and in on the tail rope drum to haul the scraper back to the loading point. The hoist weighs only 555 lb. or about 85 lb. per horsepower, is 29 in. long by 15 in. wide and stands 18½ in. high. Each drum holds 225 feet of 5/16 in. wire rope. Either drum is capable of lifting 2,000 lb. dead weight vertically, with 76 lb. of air pressure at a speed of 110 ft. per minute. Sufficient air can be supplied the machine through a ¾ in. hose line to develop the machine's rating of 6½ h. p. The hoist may be used for other work within the capacity of the machine as for example on boom derricks, where one drum is used for hoisting the load and the other for operating the boom.