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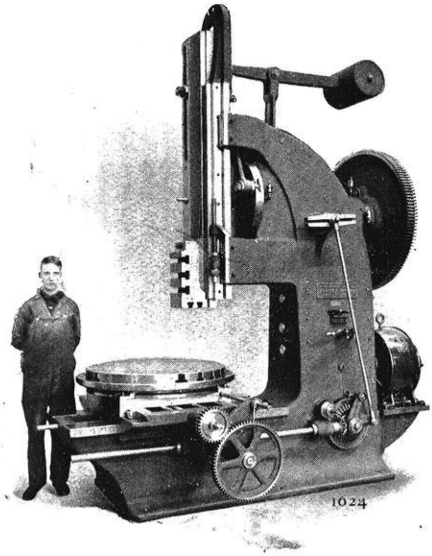

22-inch Motor Drive Slotter

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THE WISCONSIN ENGINEER

VOL. XIII FEBRUARY, 1909 NO. 2

SOME RECENT ADVANCES IN MECHANICAL ENGINEERING.*

CARL C. THOMAS,
Professor of Steam Engineering.

The past year has seen very few innovations in engineering matters, but in spite of the financial depression, considerable progress has been made in almost all of the important branches now occupying the attention of engineers.

In the field of Mechanical Engineering probably the most striking development has been that of the larger prime movers, notably the steam turbine and the internal combustion engine. The question is frequently asked, "Will not some one form of prime mover drive out of existence the other forms of engine?" Experience does not point, so far, to the probability of any one or two types of prime mover taking the place of or supplanting all the others. The steam turbine has not driven out the reciprocating steam engine; it has taken its place for certain uses, and the reciprocating engine will probably not regain the position it formerly occupied. However, the inherent qualities of the reciprocating engine are such that it is likely to remain superior to the steam turbine for certain special uses. In the same way the gas engine, while it has taken the place of the steam engine in special cases and will probably retain what it has won for a long time to come, is not so well adapted to the driving of alternating current generators in central stations, and for

* The illustrations of steam turbines and gas engines used in this article were kindly furnished by the Allis-Chalmers Co., Milwaukee, and represent the output of that company.

running many classes of machinery as is the steam turbine. The question as to the probability of hydraulic turbines driving out of use all forms of heat engines may be answered in a somewhat different way: If falling water were available within practicable distance of all places where power is desired, it is probable that it would, in connection with electric apparatus, supplant heat engines for nearly all stationary power purposes, but the fact that water power is not thus universally available assures the continuance of extensive use of heat engines for power development.

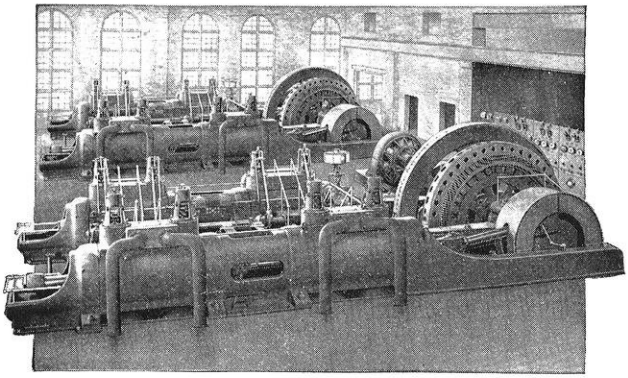

Fig. 1.—Four-cycle, Double-acting, Twin-tandem Gas Engines, each of 2000 H. P. capacity.

The effect of competition for place of first importance among prime movers has been to stimulate improvement of each type rather than to cause any one of the well established forms of engine to be driven out of the market. Each surviving type has been brought to a higher state of perfection than that which it would have reached if it had had the field to itself. It is a question not alone of relative fuel economy, but of general adaptation to specific purposes, reliability of operation, simplicity of parts, and ease of repair. It is natural that the reciprocating steam engine should lead in many of the above points because of the length of time it has been in use; but the steam turbine and the internal combustion engine are forcing themselves into important places because of their special merits and are now operating machinery in fields where the reciprocating engine formerly held full sway.

The large gas engine of from 500 to 2,000 or more brake horse power, using as fuel what was formerly the waste gas from blast furnaces, has been applied to operating the rolling mills of steel plants and to the generation of electric energy. Such engines are now coming to be regarded as the rule

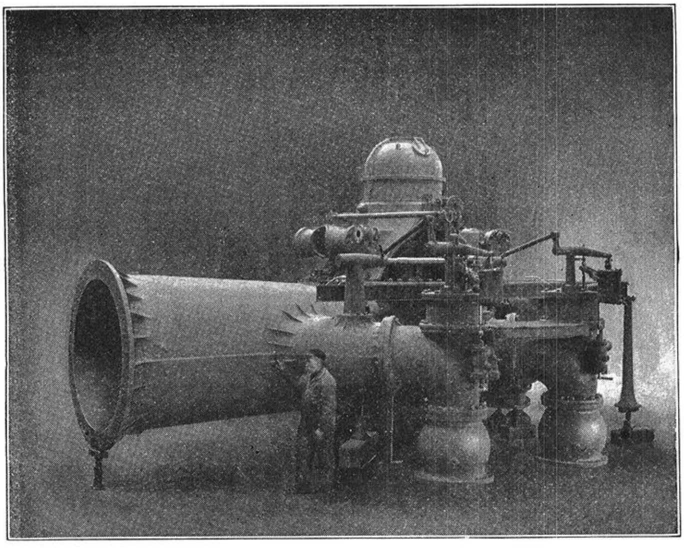

Fig. 2.—13,500 H. P. High Pressure Hydraulic Turbine. Largest Single Francis Wheel in operation in the World.

rather than the exception in steel works, and are displacing the steam driven blowing engines which formerly delivered the hot blast to furnaces for the reduction of iron ores.

Electricity is occupying a more and more important position in steel mills and the governing of gas engines has been improved so materially that central stations in connection with steel mills are being equipped with electric generators, operated by gas engines as prime movers. The difficulty of varying the speed of gas engines within wide limits and of reversing such engines has so far prevented their adoption for direct connection to rolling mills, but gas engines may be used to operate electrical generators, and ingenious systems of electric driving of such mills have com- into use and are apparently giving satisfaction in the operation of rolling mills for the production of rails and structural steel.

Large gas engines are also being used for the direct driving of high pressure pumps and in cases where such pumps are continuously operated, the service seems entirely satisfactory. If there were to be frequent stopping and starting of the pumps, the problem would be much more difficult and perhaps the gas engine would not be capable of handling the work. In this case as in that of the rolling mills, electrical means are resorted to and motors have been produced which will run with satisfactory regularity at any speed required from zero to the maximum for which the motors are designed.

In the new plant of the Indiana Steel Company at Gary, Indiana, the largest works of their kind in the world, there are to be 16 blast furnaces producing about 45,000,000 cubic feet of gas per 24 hours, equivalent, when used in gas engines, to about 300,000 brake horse power. Approximately

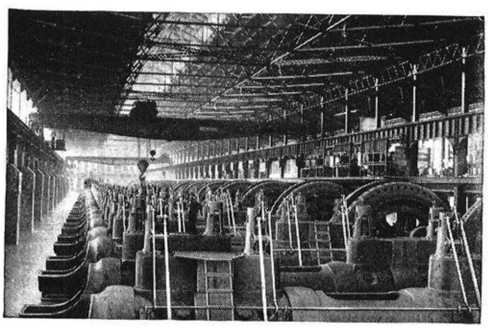

Fig. 3.—Partial View of Installation at the Indiana Steel Company's Plant, Gary, Ind., where seventeen Twin-Tandem Gas Engines are direct-coupled to Electric Generators, each unit being of 2500 K. W. capacity.

30 per cent of this gas is taken for heating the stoves supplying the hot blast to the furnaces. About $7\frac{1}{2}$ per cent is used in steam boiler furnaces, 5 per cent is used for small auxiliaries or is lost in the process of cleaning the gas, $12\frac{1}{2}$ per cent operates the gas driven blowing engines, and 45 per cent supplies the gas driven electric power-station. Each of the 16 blowing engines consists of a horizontal, twin-tandem gas engine having cylinders 42 inches in diameter by 54 inches stroke, and two direct driven blowing tubs capable of delivering 30,000 cubic feet of free air per minute against a pressure of 18 pounds per square inch. These blowing engines are so designed that they can be operated at any pressure up to 30 pounds per square inch. The gas and air cylinders of the engines are situated at opposite ends of the main engine frame. Eight of these engines were built by the Westinghouse Machine Company and eight by the Allis–Chalmers Company.

In connection with the works of the Indiana Steel Company is a large central power station, 966 feet long and 105 feet wide containing 42, 23-foot bays. The station is advantageously placed as to fuel supply and with regard to minimum lengths of transmission lines to the various departments of the mills which use electric power. In this station there are installed 17 horizontal, twin-tandem, double acting gas engines, having a rating of 4,000 H. P. each and connected to generators of 2,000 K. W., normal capacity, but capable of carrying continuously 25 to 30 per cent overload. The engines turn at a speed of $83\frac{1}{3}$ revolutions per minute. Fifteen of the engines are designed for coupling to alternating current generators and two to direct current generators. The former are 25 cycle, 3 phase, 6600 volt machines, while the voltage of the direct current generators is 250. The engines described above are said to be the largest engines in the world to operate on blast furnace gas.

The occupation of this large field of power development by the gas engine has grown very rapidly during the last year. A heavily capitalized company has been formed in the iron producing districts of England for the purpose of utilizing the waste gases from blast furnaces and distributing electrical energy to power users in various parts of England. The hitherto unprecedented scale upon which the United States Steel Corporation has entered on the use of power development by means of gas engines has created great interest in such installations all over the world. At the works of the Illinois Steel Company, South Chicago, are four gas engines of 4,000 H. P., each direct connected to a 2,500 K. W. alternating current generator, and in one of the Carnegie plants, near Pittsburg, eight similar units are being installed.

The installations mentioned serve to indicate the immense field which gas engines are coming to occupy in one of the world's greatest industries, that of making steel.

The energy developed from blast furnace gas by means of gas engines may be distributed for power and lighting purposes to distant points as well as used in the operation of the rolling mills in connection with blast furnaces, so that the latter become sources of power, serving various kinds of engineering enterprises.

Aside from blast furnace gas, the gas produced from coal of various grades, and even from some lignite and peat, offers the most promising solution of the fuel question as applied to internal combustion engines of large size. It is safe to say that the most important work in developing satisfactory producers has been done in Germany where large plants are in operation using cheap fuel and generating power at a surprisingly low cost. One of the chief lines of improvement during the past year or two has been in the methods used for cleaning the gas after it leaves the producer. When operated with high grade anthracite coal, there is very little tar in the gas coming from the producers, but when the cheaper grades of fuel are used it becomes necessary to employ special means in order to extract tar and dust from the gas. This is done in part by passing the gas through water chambers, or scrubbers, and in some cases by the use of what are called re-circulating producers in which the gas, after having been formed in the upper part of the producer, is led to the bottom of the bed of fuel by an external pipe and is caused to pass upward through the incandescent fuel in the bottom of the producer, after which it is taken off at a point about half way up the producer.

The application of internal combustion motors to driving motor cars has undergone rapid development during the past year. No revolutionary discoveries have been made in this field during that time, but improvements in details have been continuous.

A new type of gasoline engine has been developed for motor car propulsion by the Daimler Company, in which, instead of the usual poppet valves and gear, the inlet and exhaust ports are operated by means of sliding sleeves in which ports are cut. The sleeves are caused to move up and down between the piston and the cylinder walls by means of eccentrics carried upon a shaft which is driven by chain gearing from the crank shaft of the engine. The engine is said to run silently and well, even at slow speeds, but it remains to be proved how succcessful it will be as regards wearing qualities and freedom from difficulties attending complex design. Another important advance in automobile engine construction consists in arranging for the circulation of the cooling water on the thermo-syphon principle, with large flow and return pipes, instead of circulating the water by mechanically operated pumps. This change has been made on a number of recently designed engines. The design of automobile engines is continually advancing along lines of greater accessibility and simplicity, more positive lubrication, and, in general, greater reliability.

Turning from the subject of internal combustion engines, the generation of power by means of steam has undergone steady development, principally with regard to the steam turbine. The development has been along two lines: First, improvement in mechanical detail, leading to more simple construction and greater reliability, accompanied by more satisfactory methods of manufacture and the production of certain well-defined types of turbine. The most prominent types in use are, first, the Parsons, or many-stage reaction type; second, the Curtis, several-stage, velocity-compounded impulse type; third, the Rateau, several-stage, impulse type, compounded with respect to pressure only, instead of with respect to both pressure and velocity, as in the Curtis type. Based on the general principles of these three kinds of turbine, a large number of types more or less closely related to these has appeared, within the past six or eight years, each type bearing the name of its inventor.

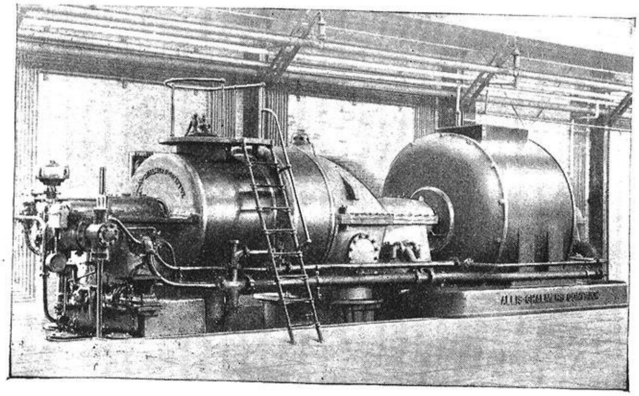

Fig. 4.—3,250 K. W. Steam Turbine and Generator.

The second line of improvement has resulted from better understanding on the part of designers of the heat changes that go on within their machines; that is, of the thermodynamics of steam flow in the various types of turbine.

Much remains to be done in steam turbine analysis, both from the mechanical standpoint, and from that of thermodynamics, but already many important improvements have been brought about. Some of these have been, the production of more homogeneous steel for turbine rotors; special material for blades, adapted to withstand the action of rapidly moving steam; such arrangement of parts as will permit of the use of superheated steam of high temperature without undue distortion, and consequent vibration and pos-

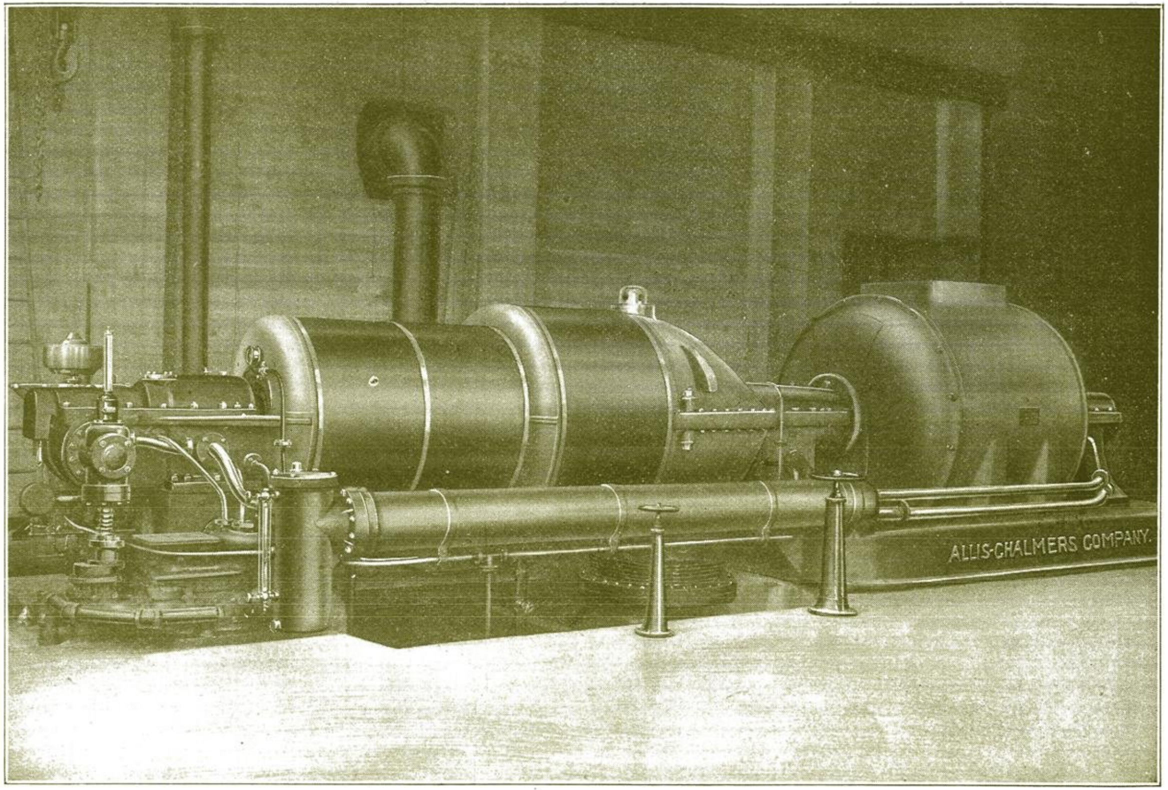

Fig. 5.—1500 K. W. Steam Turbine and Generator installed in a cement plant.

sible destruction of moving parts; better and more sensitive governing devices; and improvements in methods of supplying oil to bearings. Besides these, methods of construction have been adopted in some types of turbine permitting larger working clearances between moving and stationary parts to be used without undue loss by steam leakage through the clearances. Five years ago, the largest steam turbine units built were designed for normal load of about 5,000 kilowatts. Now, units of from 10,000 to 12,000 kilowatts are not uncommon.

At present one of the most promising fields in power development is that in which the reciprocating steam engine and the turbine are combined; the engine using high pressure steam of from 150 to 200 pounds per square inch by gage and expanding to about atmospheric pressure, the turbine using the exhaust from the engine and expanding it to a vacuum pressure of about one pound absolute, or, in some cases, one-

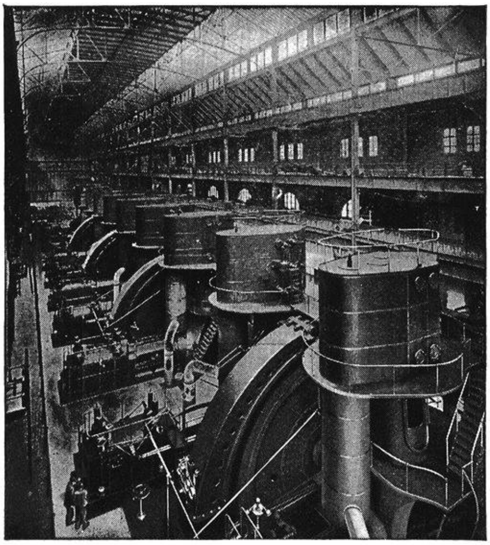

Fig. 6.—Nine 12,000 H. P. Engines installed in Subway Power House of the Interborough Rapid Transit Co., New York.

half pound. Combinations of this sort are being used both for stationary power purposes and for the propulsion of vessels. The results are improvement in economy of fuel, in the amount of power developed per unit of weight and space occupied, and, in the case of marine work, the combination gives greater facility in maneuvering vessels, and greater economy at slow speeds than is possible in an all-turbine installation. Some of the largest vessels ever built are at present under construction at Belfast, Ireland, for the White Star Line, to be equipped with this combination system, which is the result of several years' experience in the application of the turbine to marine propulsion. During this time the giant Curnarders "Lusitania" and "Mauretania," with an all-turbine arrangement yielding 65,000 horse power, and driving the vessels at 25 knots speed, have been in service. They have been remarkably successful considering that they were more or less in the nature of experiments in a hitherto untried field. It is significant that vessels of similar type, designed in the light of experience, are being equipped with the combination system.

With the development of the steam turbine, has come the necessity for measuring the power it delivers. This necessity has brought forth the invention of the torsion-meter. Heretofore, indicated horse power, calculated by means of diagrams showing the pressure existing in steam engine cylinders has been the universally accepted standard for comparing the output of steam engines. A steam-turbine cannot be "indicated." It can be tested by means of a brake, and the result is what is known as "brake horse power." But a brake is difficult to apply to a shaft, under the conditions usually existing, especially on ship board. As is often the case, an investigation begun with one specific object in view yielded two-fold results. That is, Mr. Herman Frahm, of Hamburg, was commissioned to find out why marine engine shafting so often broke under the turning effort put upon it. A determination of the extent of angular distortion of the shafting under known turning efforts was part of the information necessary to his investigation. Having obtained means for measuring this, it was only a step to working the inverse of this problem, namely, if the angle of torsion of a given shaft the elastic properties of which have been determined by experiment, be ascertained by measurement, when turning at a given speed, how much power is being delivered by the turbine

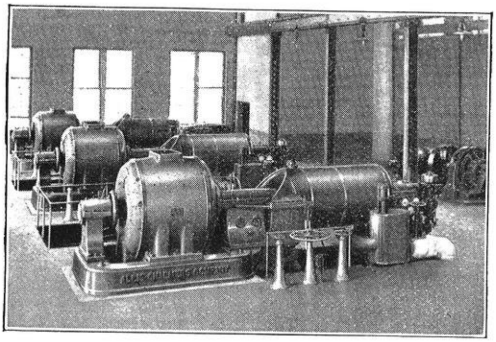

Fig. 7.—Three of Four Steam Turbines and Generators, 5500 K. W. Capacity, in a Textile Mill.

or other engine, which is causing the shaft to rotate? As soon as the nature of the problem was recognized, instruments were devised for measuring the angle of torsion of shafting in motion, and such instruments are called torsion-meters.

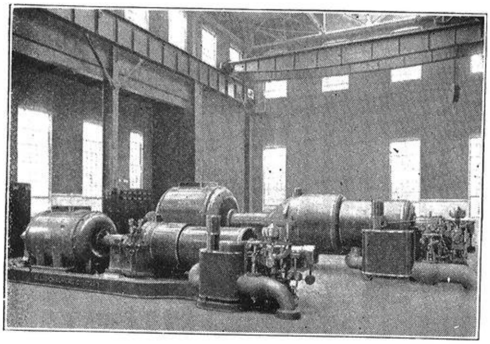

Fig. 8.—500 K. W. Steam Turbines and Generators installed in the power station of a large industrial system.

Some of them are automatic recording devices, some indicate delivered horse power directly on a dial, while others depend for their record upon sounds transmitted by the telephone. The results of this invention have been far-reaching. Not only can the power delivered by turbines be measured, but that of reciprocating engines can be equally well determined, and this latter, combined with information as to the indicated horse power, has enabled engineers to solve the vexed problem as to the mechanical efficiency of large reciprocating steam engines. It had been customary to assume this efficiency at from 85 per cent to 90 per cent, with the emphasis on the 85 per cent. The torsion-meter has shown it to be more nearly 95 per cent. That is, that a well designed reciprocating steam engine of large size delivers perhaps 94 per cent or 95 per cent of the power given up to it by the steam working in the cylinders, instead of from 85 per cent to 90 per cent, as was formerly assumed. This has been one of the recent great achievements in mechanical engineering.

Another notable improvement has been the development of more satisfactory apparatus for producing superheated steam, for use in turbines and other engines, and resulting in greatly improved economy.

Again, the turbine has called for a better vacuum in the condenser receiving its exhaust steam, and this requirement has been promptly met by the production of condensers very much more efficient than have ever before been constructed.

In certain cases internal combustion engines and steam turbines are being installed together, in electric power stations, with a view to obtaining cheaper power than is available from either steam or gas engines alone. The heat of the gas engine exhaust, and that from the cylinder jackets, may be used for heating the feed water for the boilers supplying steam to the turbines. Where the gas engines can be fed with producer gas made from low grade fuel, or where natural gas is available and cheap, the economy of the gas engine is such as to render it a very desirable element in the power station. But when the cost of gas is high, the advisibility of installing gas engines is very questionable. In any event, where the combination system is used, the steam turbines, or else reciprocating engines, are used to take care of variations in load coming on the station, as the latter are very much more easily governed during wide variations of load, than are the internal combustion engines. The latter are especially suited to carrying constant loads, while a steam turbine will take care of sudden variations from zero load to full load, with very little variation in speed of revolution.

The proposal so often made, to apply producers and internal combustion engines to the work of ship propulsion, has been tested by the installation on the British ship "Ranger," in use by the Clyde Brigade of the British Naval Volunteers. This vessel has made long cruises, with satisfactory results, from the points of view of maneuvering and of fuel economy. There exists at present considerable difference of opinion in engineering circles as to whether the producer-engine combination or the engine using liquid fuel will be best adapted to the propulsion of large ships. Of course, the general question as to the practicability of applying internal combustion engines to large ship propulsion is still open, it cannot be said to be near solution at the present time. For relatively small vessels, up to about 125 or 150 feet long, gasoline engines are being successfully used and are very satisfactory owing to the lightness of the machinery and the readiness with which a boat so fitted can be got under way. It is probable that the use of gasoline engines in marine work will be confined to relatively small ships, the heavier internal combustion engines, using either producer gas, or else the heavier oil fuels, being preferable for large installations aboard ship.

No account of even the most impressive recent improvements in mechanical engineering would be at all comprehensive if it failed to mention the great progress that has been made in the art of cutting metals; or, in other words, in the art of producing high grade tool steel. A few years ago, one of our greatest steel works, turning out machine-finished products as well as the raw material, was facing the apparent necessity of doubling the size of its buildings and general equipment in order to cope with its growing business. At the critical time, the problem was met in an unexpected manner. Instead of enlarging the works, some bright fellows found a way to make tool-steel that would maintain a cutting edge when taking off metal in a lathe or other machine tool at double the rate of speed formerly used. It was thus possible on the same floor-space to turn out about twice

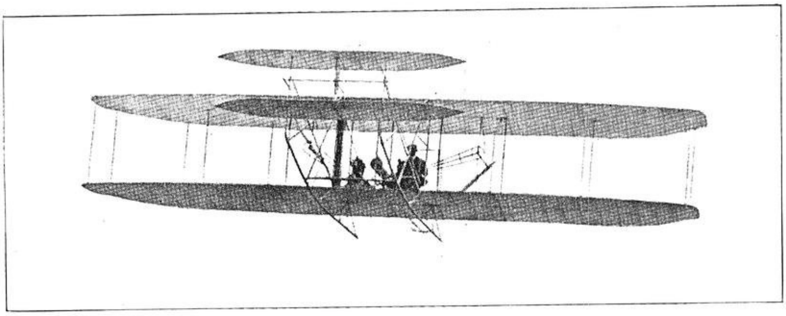

Fig. 9.—Wright Brothers' Aeroplane, Fort Myer, Va., Sept. 9, 1908.

the work formerly produced. This improvement, however, could in many cases be taken advantage of only by replacing the machine tool equipment with new and stronger machine. The introduction of what are called "high-speed tool-steels" at once became general. The advantage to large as well as small concerns was unquestionable. It has been followed by the appearance of many brands of special steels, each claiming superiority because of certain special properties conducive to the rapid cutting of metals.

There have been many other important developments during the past year or two such as improvement in steam locomotives, which has undoubtedly been stimulated by the increasing application of electric traction in fields formerly occupied by steam locomotives alone; proposed mono-rail transportation; advance in sub-marine boat engineering; and the vast array of improvements in electrical engineering.

In the mind of the general public, the most interesting of the developments of the past year or two are undoubtedly those concerning the art of mechanical flight and that of wireless telegraphy. In our own country and in Europe, notably in France and Germany, the development of the art of mechanical flight is receiving more and more serious attention at the hands of men of high position and great intelligence. A year or two ago the possibility of obtaining practical re-

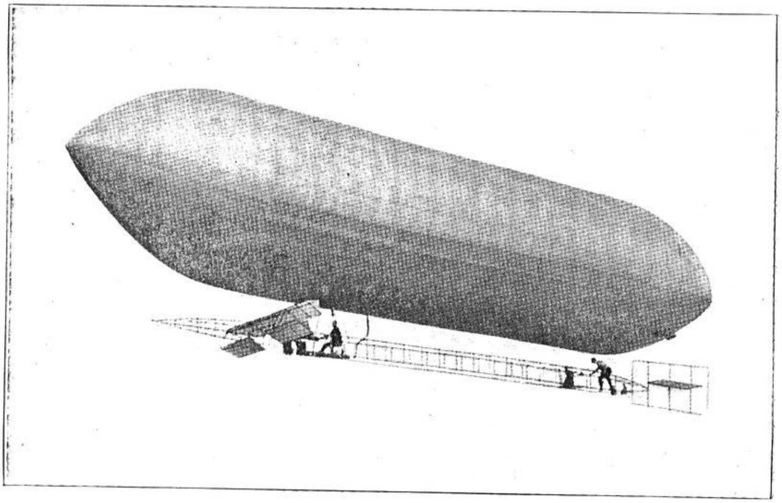

Fig. 10.—Signal Corps Dirigible No. 1, in Flight, Fort Meyer, Va., August, 1908.

sults with a machine capable of rising in the air and being propelled and steered by a human pilot was contemplated only by a few enthusiasts, and was a subject chiefly of interest to the cartoonist and the editor of the funny paper. To-day it is a promising possibility. Both the aeroplane and the motor baloon are limited thus far by the impossibility of navigating with them in anything like rough weather, but interesting progress is being made by both. The principles underlying mechanical flight are now clearly understood, but it is by no means certain that the practical flying-machine of the future, if there is to be one, will much resemble either the dirigible balloons or the aeroplanes which are now in the experimental stage. It is certain that far less progress would have been made during the year if it had not been for the wonderful accomplishments of Wilbur and Orville Wright. They have introduced new principles, quite different from those upon which the French experimenters have based their designs. Competition is keen between the advocates of the various systems that have been proposed. Each new achievement is watched with enthusiasm by the public, and with serious interest by those in charge of military affairs in all civilized countries.

A NEW FIELD FOR ENGINEERING GRADUATES.

BY W. D. PENCE,
Professor of Railway Engineering.

One of the most interesting phases of the industrial development in this country during the past quarter of a century has been a steadily increasing capacity to assimilate the output of our engineering schools. Statistics* for the school year 1901–2 show a total enrollment of 16,433 students in all departments of engineering at the 114 institutions in the United States which then offered engineering courses. The seven-year period since these figures were compiled has seen a marked growth † of attendance at most schools of engineering in this country and there has been a similar increase in the enrollment of students in correspondence schools offering technical courses. The grand total of these enrollment figures, if available, would perhaps best indicate the magnitude of this educational movement or tendency, particularly if placed in contrast with similar figures of ten and twenty years ago. Such figures would startle even the closest student of such matters unless he should view them in their true relationship to the industrial and social developmentof the country during the same period.

Viewed narrowly, the cold figures might easily lead one to conclude that there is already a large over-supply of technically trained men, and this view is often entertained by engineers and others who, perhaps naturally enough, give undue weight to their experiences during slack times. But even these times of lull often appear to serve a valuable purpose in causing many engineers to turn their attention to other

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*Proceedings Society Promotion of Engineering Education, Vol. X, p. 239.

† The total enrollment of engineertng students in 1905–6 was 26,910. (Report Commissioner of Education, 1906, pp. 510–528.)

and often more profitable fields of employment, a movement which not only tends to relieve the stress of competition in the engineering profession itself, but also gives stimulus to the other fields of professional and commercial activity which thus gain valuable recruits. Such diversion of engineers to other fields of work brings to mind the arguments often advanced by engineering educators with respect to the value of an engineering course as a fundamental training for a business career. That the soundness of this suggestion is coming to be appreciated is shown by the increasing numbers of students enrolled in engineering courses with such plan in view.

In tracing out the almost innumerable channels through which engineering graduates, and the underclassmen as well, find or make opportunities to apply their technical training, special interest is found in certain of the lines which have only recently opened up, and some of which are still in the earliest stages of development.

One of these pioneer fields which gives much promise for future activity for the engineering graduate relates to the regulation of "public service" or "public utilities" properties, which within the past two years has been taken up by the states of New York and Wisconsin, and which is quite certain to be the subject of similar legislative enactment by other states in the immediate future.

It is the purpose of this article: (1) to outline some of the technical features of this state engineering work* as already developed in Wisconsin, and (2) to call attention to a closely related field of work which now gives promise of excellent opportunities to the engineering graduate.

I. WORK OF THE WISCONSIN STATE ENGINEERING STAFF.

There is now employed in joint service under the direction of the Railroad Commission of Wisconsin and the Wisconsin State Board of Assessment a staff of engineers, inspectors,

*For a more complete description see paper on "The Work of the Joint Engineering Staff of the Wisconsin Tax and Railroad Commissions" (*Journal Western Society of Engineers, February, 1909*).

computers, etc., engaged in the technical work relating to the regulation of service of the so-called "public utilities" properties, which under the Wisconsin statute include waterworks, gas, electric, heating and telephone plants, and in the valuation of the physical properties of these utilities and the steam and electric railways of the state for rate making and taxation purposes.

The scope of the work done by the staff both as to valuations and to inspections and investigations of service is set forth in the following outline:

OUTLINE OF ORGANIZATION OF ENGINEERING STAFF.

1. *Administrative.* Consisting of the engineer, assistant engineer and heads of departments, responsible for the direction of the work.

2. *Office Staff.* Consisting of a special office staff; also members of the regular field staff while same are working up field notes. Engaged in the reduction of field notes, the compilation of valuation and other reports, and the systemtaic collection and filing of cost data and other records.

3. *Civil Engeneering Staff.* Engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are customarily purchased, constructed, or maintained under the direction of civil engineers, including such items as the following: Lands, track, track structures and bridges; buildings and miscellaneous structures, such as gas holders, standpipes, reservoirs, dams, wells and foundations; earthwork and paving; pipe distribution systems for water, gas and steam heating plants, including tunnels for same; office furniture and appliances; horses and wagons; tools, stores and supplies pertaining to the foregoing items, etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of railways, water-works plants, etc.

4. *Mechanical Engineering Staff.* Engaged in the inspection and valuation of those details of the physical prop-

erty of steam and electric railways and public utilities plants which are customarily purchased, constructed or operated under the direction of mechanical experts or engineers; including such items as the following: Power plant machinery and equipment (exclusive of electrical features); steam and hot water plants (except street mains); steam road locomotives and rolling stock; shop tools and machinery; tools, stores and supplies pertaining to the above items, etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of water-works, heating plants, power plants, etc.

5. *Electrical Engineering Staff.* Engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are unusually constructed, purchased or operated under the direction of electrical experts or engineers, including electrical machinery and appliances in power plants and elsewhere; electric railway rolling stock; electrical distribution systems, overhead and underground; telephone plants; signaling appliances; tools, stores and supplies related to the above items, etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of electric railways, power plants, telephone properties, etc.

6. *Gas Engineering Staff.* Engaged in the inspection and valuation of machinery and appliances for the manufacture of gas; tools, stores and supplies pertaining to the same, etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of gas plants.

7. *Gas and Electric Service Inspections.* Engaged in inspections and investigations of gas and electric service; studies with reference to the establishment and revision of standards of service and the formulation of rules for the same; tests and calibrations of instruments used in service measurements; investigations with reference to the electrolysis of water and gas mains, etc. Also investigations, in

co-operation with other departments, with a view to suggest improvements in the operating conditions of gas and electric plants.

8. *Miscellaneous.* Experts engaged temporarily for special service of various kinds, either independently or in co-operation with one or more of the foregoing departments. Such service hitherto rendered has included such matters as the following: Consultation with prominent architect relative to valuation of a costly city building; service of expert in investigations as to the safety of important bridges; expert valuation of the horses, harnesses, etc., belonging to a large electric railway and lighting company; expert assistance in establishing a basis for valuing street railway special work; consultations with respect to improvements in street railway service, etc.

The staff regularly engaged in this service consists of about thirty-five persons, of whom about thirty have duties related specifically to the engineering or scientific phases of the commissions' work. Of these thirty technical men all but three are university graduates, and two of the latter are members of the present senior class in the College of Engineering of the University of Wisconsin. In addition to the regular staff above referred to, the services of five or six other experts are used as occasion requires, raising the entire engineering or scientific staff to about thirty-five. Some seven of the regular staff are members of the teaching force of the College of Engineering, as are also five additional experts called upon occasionally to assist in special inspections and investigations.

LIST OF ENGINEERING STAFF POSITIONS.

Engineer in Charge (reporting to the two Commissions).
Assistant Engineer (office engineer).
Civil Engineer Inspector.
Chief Mechanical Inspector.
Chief Electrical Inspector.
Expert on Light and Heat.

Field Mechanical Inspector.
2 Field Electrical Inspectors.
Inspector of Gas Service.
Inspector of Electric Service.
6 Assistant Field Inspectors (Civil Engineering).
3 Assistant Field Inspectors (Mechanical Engineering).
2 Assistant Field Inspectors (Electrical Engineering).
4 Assistant Inspectors of Gas and Electric Service.
4 Engineering Computers (Civil Engineering).
5 Stenographers and clerks.
Messenger.

For Occasional Service.

Consulting Engineer (street railways, etc).
Experts and inspectors in electric and gas service, bridge investigations, etc.

For reasons of economy or efficiency it has been found expedient in some cases temporarily to combine, and in still others to subdivide, the duties and responsibilities of certain of the positions given in the foregoing list. At the present time, for example, the assistant engineer performs the duties of office engineer and, in a measure, of the civil engineer inspector as well. Similarly, the expert on light and heat is at present chiefly responsible for the staff work of the two related departments of gas engineering and gas and electric service inspections. The duties of chief electrical inspector, on the contrary, are at present shared by two field electrical inspectors, responsible for the inspections and valuations, one primarily of the electrical machinery and rolling stock group, and the other of the electrical distribution systems and telephone properties.

It should be stated that membership on the staff is based upon ascertained fitness for the special service for which the appointment is made and is controlled by the rules of the State Civil Service Commission, except in the case of certain lines of expert service relating specifically to the work of the Railroad Commission. There is entire freedom from political or other influence both in the matter of appointment and in the tenure of position on the staff. The tenure of service has been quite stable, the list except for the additions being much the same as that established in February, 1907, when the engineering staff roll was increased from three to twenty-three names. The practice followed in the other departments of the state commission service of requiring each employe to report daily the actual hours devoted to the state work, is observed by the technical staff.

The following figures may convey some idea as to the magnitude of the valuation work regulary performed by the staff:

SUMMARY OF RECENT PHYSICAL VALUATIONS MADE BY THE JOINT ENGINEERING STAFF OF THE RAILROAD COMMISSION OF WISCONSIN AND THE WISCONSIN TAX COMMISSION.

	Cost of Reproduction.	
	Property New.	Present Condition.
(a) *Steam Railroad Properties.*		
Fifty-two (52) properties aggregating 7,090 miles; inventory date June 30, 1907; fourth annual re-valuation under the 1903 ad valorum law	$244, 128, 868	$196, 239, 314
(b) *Street Railway Properties.*		
Twenty-four (24) street and inter-urban properties with ten (10) associated lighting and heating properties; inventory date June 30, 1907; first valuation under 1905 ad valorem law	$ 26, 783, 620	$ 21, 208, 010
(c) *Public Utilities Properties.*		
Twenty-four (24) public utilities properties; varying inventory dates; valuations under 1907 law	$ 6, 405, 521	$ 5, 440, 605
(d) *For Stock and Bond Issues.*		
Five (5) properties valued and reports made under 1907 law	$ 305, 576	$ 270, 008
	$277, 623, 585	$223, 157, 937

The steam and electric railway properties are re-valued each year primarily for the purposes of the State Tax Commission. The public utilities law calls for the valuation, and also for periodical re-valuations, of the public utilities properties of the state, chiefly for rate regulation and accounting purposes. According to the 1909 report of the Railroad Commission, there are at the present time some 1,005 utilities properties, publicly and privately owned, in the state of Wisconsin, classified as follows:

Gas	52
Electric light and power	230
Water	141
Telephone	569
Heating	13
Total	1,005

No attempt will here be made to enter into a detailed description of the inspection and special investigation work performed by the scientific staff. Important progress has been made by the Railroad Commission in the interpretation of the provisions of the utilities law respecting standards of gas and electric service, and in this work the University of Wisconsin has rendered most valuable assistance by opening its laboratories to the scientific staff of the Commission. The work of establishing standards of service and methods of testing has also received valuable aid through the co-operation and sympathetic support of the United States Department of Standards and of the Standards Committee of the American Gas Institute. The results of these investigations are embodied in an important decision by the Railroad Commission, entitled "*U–21. In re Standards for Gas and Electric Service in the State of Wisconsin*," and issued under date of July 24, 1908. Routine inspections are currently made by members of the staff under these rules of service.

Investigations have also been made and reports submitted by direction of the Commission touching the quality of service rendered by water-works, both privately and publicly owned, and by heating and telephone companies. Reference has also been made to a further line of miscellaneous work which in the aggregate requires a considerable amount of time from the staff. The nature and scope of these duties are indicated by the following headings:

1. Supervision of interlocking and signaling installations at railroad crossings and drawbridges.
2. Investigations of railroad accidents.
3. Investigations as to the safety of track and bridges.
4. Investigations as to the protection or separation of crossings between highways and railroads.
5. Reports on proposed industry tracks.
6. Examinations relative to specifications for proposed railway construction and inspections of newly completed lines in advance of operation.
7. Investigations of street railway service.
8. Investigations in rate cases.
9. Advisory service in the operation of public utilities plants.
10. Other engineering or related service for either commission.

For a more detailed statement concerning the work of the Wisconsin engineering staff, reference is made to the 1909 reports of the two state commissions, and to the paper already mentioned. Some idea of the cost of maintaining this joint engineering staff is to be gained from the figures in the accompanying table taken from the annual report of the Railroad Commission. It will be noticed in this table that active work on the public utilities was not begun by the engineering staff until October, 1907, some three months after the enactment of the utilities law.

EXPENSE OF ENGINEERING STAFF—RAILROAD AND TAX COMMISSIONS

June 30, 1907, to June 30, 1908.

Month.	No. on pay roll.	Public Utilities		R. R. Com. Except Public Utilities.		Tax Commission.		Grand Total.
		Salary.	Expense.	Salary.	Expense.	Salary.	Expense.	
July..........	17	....	....	$1,002 01	$158 99	$1,002 01	$158 99	$2,322 00
August........	18	....	....	955 97	265 93	955 97	265 93	2,443 80
September....	17	....	....	778 16	115 51	778 16	115 51	1,787 34
October.......	18	$335 16	$114 49	725 03	24 43	725 04	24 44	1,948 59
November.....	22	584 99	100 03	829 66	28 00	829 68	28 00	2,400 36
December.....	21	700 48	132 92	725 46	118 40	725 45	118 40	2,521 11
January.......	26	1,282 81	109 47	608 10	51 04	608 10	51 05	2,710 57
February,.....	30	1,139 86	291 92	732 72	63 03	732 72	63 03	3,023 28
March.........	26	1,524 98	671 07	481 08	52 41	451 07	8 89	3,189 50
April..........	26	1,557 41	241 76	472 93	12 36	442 92	8 39	2,735 77
May...........	25	1,695 15	550 53	395 04	23 56	365 02	....	3,029 30
June	25	1,644 17	455 30	509 00	....	479 00	....	3,087 47
Total......	av. 22	$10.465 01	$2,667 49	$8,287 16	$913 66	$8,167 14	$842 63	$31,343 09
Grand total.	....	$13,132 50		$9,128 82		$8,997 77		$31,199 09
Per cent.......	....	42%		29%		29%		100%

NOTE. This table is reprinted from the 1909 report of the Railroad Commission of Wisconsin.

II. OPPORTUNITIES FOR ENGINEERING GRADUATES.

In conclusion attention will be called to a line of professional service which is closely related to that above described and which gives promise at this time of opening up a wide field of opportunity for engineering graduates.

It is reported that most of the state legislatures now in session have under consideration bills contemplating the adoption of state supervision of public utilities properties, in a number of instances on the Wisconsin plan. With the spread of this movement to only a few additional states, the number of utilities properties to come under commission control may soon reach many thousands; for, as already noted, there are, in round numbers, one thousand such plants in Wisconsin alone.

The opportunities thus to be opened up to engineering graduates are likely to be of the highest importance. Many with proper qualifications will find service as experts for the newly created state commissions along lines similar to those above described, but a much greater number will be demanded in the operation and business management of the utilities plants themselves. This latter field already engages the attention of a large number of engineering graduates, but the demand for first-class men with the higher technical training and the broader view of things will steadily increase with the expansion in the public knowledge with respect to better standards of service.

No attempt will here be made to discuss in detail the merits of this expanding field of professional work. It is not to be supposed, for instance, that the difficult problems are confined to the large plants; some of the most perplexing tangles, in fact, occur with the plants of smaller size. Nor are the merits altogether with the privately owned as against the municipal plant, nor vice versa. Throughout will be found ample need for the play of all the "tact and talent" that can be brought to bear. It is the man of technical training, in a particular sense the man who has accepted the bounty of the state—the graduate of the state university—who should be quick to do his share in good spirit towards the solution of these and related problems which so vitally touch the happiness and business welfare of the community in which he lives. In meeting these obligations, technical ability of the higher order is, of course, essential to the success of the manager of public service properties, but more essential still are these qualities of manhood and character which are too often regarded lightly in the business world—an unswerving integrity, the sense of justice, ability to see the other side of things and to meet people half way, patience to wait if need be, tact without deception, and so forth. The university training of the future, we may hope, should do even more than in the past towards instilling and stimulating these and other qualities which make for better citizenship.

HUMAN CHARACTERISTIC CURVES.

BY FREDERICK A. DE LAY, '02.

Being by nature a curve fiend, this individual has plotted curves for almost everything imaginable. One set of curves which will be explained here has been called human characteristic curves. Human, because they do not follow exact laws, and characteristic because they hold the same relation to the make up, of the human being, that a shunt, series or compound characteristic, holds to their respective machines; and you will notice that there is a very great similarity between human characteristic curves shown and the characteristic curves of electrical machinery. This may be explained by the fact, that the particular person, whose characteristics are here shown, has spent most of his life with electrical machinery, and since a person's companions may influence his character they may have influenced this person's characteristics.

The most interesting curves are those relating to finance. When first married, it puzzled this man greatly to see that two could not live as cheaply as one. He therefore kept very careful account to see, when and where, that filthy lucre disappeared. He plotted curves from the data thus obtained in order to see at one glance the rate at which it disappeared. Fig. I. shows the usual form of the curve. (Note the similarity, to the speed flux-curve of a motor.) In fact it was so persistent in its shape that a template was made and data are no longer taken for this curve. The equation of the curve is approximately of the form of $xy =$ constant, in which the constant is the amount of the salary per month, x is a variable from 1 to 30 or 31 instead of zero to infinity, and y therefore varies from zero to the value of the ccnstant. In other words when money is plentiful (on pay day and a day or two later) it disappears at a very rapid rate, and when money is scarce, a little goes a long way, as shown by the tangent to the curve. If in such a curve y always has a fair size plus value, it would indicate that that particular individual is a good financier; if y becomes negative he is a spendthrift. In the case considered it seems as though a kind providence governed the rate at which the money disappeared so that

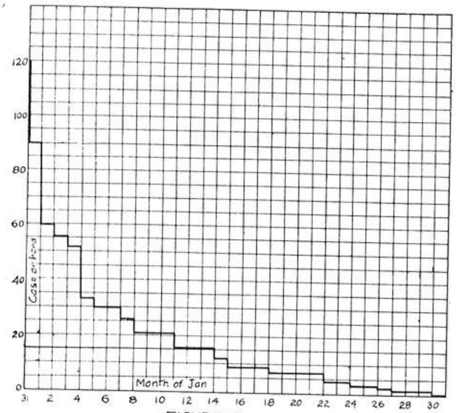


FIGURE I.

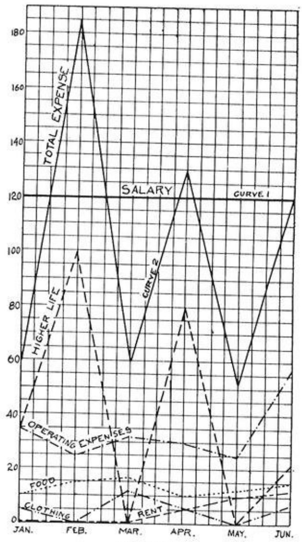


FIGURE II.

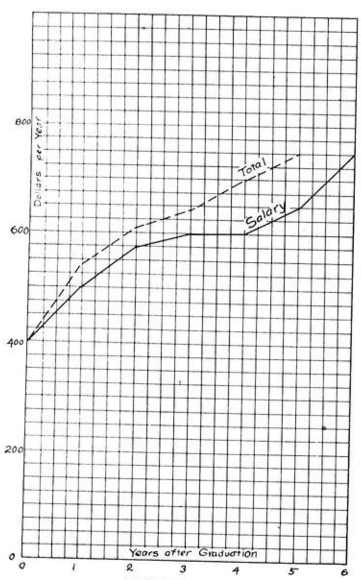


FIGURE III.

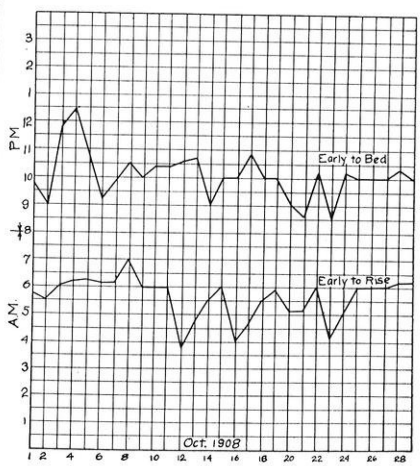


FIGURE IV.

this particular individual should always have an incentive to work and welcome pay-day with a "Quaker Oat" smile.

Figure II. is a monthly analysis of Fig. I. Curve 1, figure II, represents the monthly salary, a constant, curve 2 the total expenditure each month. The other curves are the expenses that form part of the total. Note that food, clothing, rent and incidentals are a small part of the total, and that the total follows the higher life line, i. e., money spent for books, magazines, music, theater, etc., in fact, things that are not absolute necessities. Notice also the pendulum characteristic of the monthly total. January with small amplitude swings below the salary, February above, March below, April above, May below, the amplitude growing less until in the month of August its amplitude would probably be quite small, and thenceforth remain below the salary. It would then undoubtedly start to swing again with increasing amplitude, but the curve does not show more than six months.

Figure III. is of the nature of a fortune teller; it shows the past and a slope of the curve reveals somewhat of the future. Since the person under consideration graduated from college his salary has steadily increased, but the curve begins to show a tendency to become horizontal. His only satisfaction is that the total income curve is still increasing at quite a rapid rate. In this particular case the characteristic curve resembles very closely the external and total characteristic of a highly over-compound generator, the salary, immediately after graduation, corresponding to no-load voltage, the bend in the curve to the point of saturation, and although the external characteristic may droop finally, the total should not come below its maximum value. The slope of the first portion of the curve would indicate the material of which the young man is composed. If these curves should resemble the characteristic curve of a shunt generator, or differentially compound (one that goes down from the start), the case is a sad one, and as soon as discovered he should be started over again on the right road.

Figure IV. shows a characteristic, which in a measure may explain the shape of the characteristic curves of figure III. The curves are the sleep characteristics. It will be noted that these curves indicate a very erratic disposition, but the general average of the curves is not altogether bad. The relation between curves of figures III. and IV. should demonstrate the truth of the saying "Early to bed and early to rise."

These are only a few of the many possible human characteristic curves. Plot your own and mend your ways accordingly. It is hoped that all of your curves may be an improvement over those considered above.

THE NEW ROAD BALLAST OF THE UNION PACIFIC RAILROAD

ELIOT BLACKWELDER, Department of Geology

Whatever may have been the condition of the Union Pacific line in its checkered career of the past forty years, even one without special knowledge of railroad matters, like myself, could not fail to notice that its new roadbed and line equipment through Nebraska and Wyoming are of the best quality.

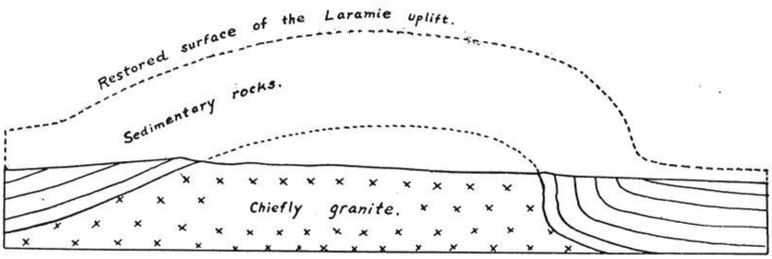
My attention was drawn particularly to the material with which the road is ballasted. Not far west of Omaha I noticed that the ties were laid in what seemed to be crushed granite. This surprised me, inasmuch as no granite could be obtained nearer than the Rocky Mountains, several hundred miles away. Afterward I found that the road has been dressed with this material not only the full length of Nebraska, but across Wyoming as well, and that all of it came from a single excavation.

When traced to its source this supposed crushed granite turns out to be a natural product, already available in the loose form. It is merely excavated like gravel, and is then ready for immediate use.

The excavations are located at the station of Buford, near the top of the Sherman divide (8,000 feet elevation), between Cheyenne and Laramie, Wyoming. There a pit more than half a mile long has been dug in the level grassy surface of the plateau. Heavy steam shovels gnaw the gravel from the bank and load it directly into cars on parallel tracks. The methods are essentially the same as those used in the great open-pit iron mines of the Mesabi district of Minnesota. Light blasting is required to loosen the mass ahead of the shovels, but no other treatment is necessary.

As taken from the pit, the material is coarse, angular rubble, consisting of rough crystals of pink feldspar, with more or less quartz and mica adhering to them. In the bottom of the pit, which was about fifty feet deep at the time of my visit, several pieces of the underlying bed-rock had been blasted out. These consisted of the same minerals as the gravel above, with the addition of dark green hornblende. An inspection of the walls of the pit and the surrounding country brought out the fact that the gravel was indeed only the rotten surficial portion of the great mass of coarse-grained granite which underlies the plateau.

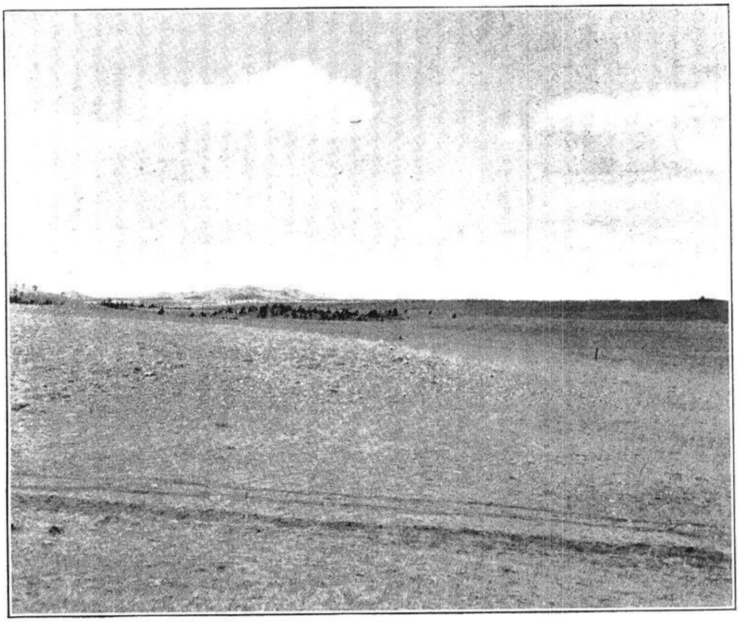
The origin of the gravel is apparently about this—At the close of the Cretaceous period a broad arch was formed along



(*Fig. 1. Diagram of the Laramie uplift before and after the denudation.*)

the present axis of the Laramie hills. In the ensuing ages this was slowly denuded and eventually worn down to nearly a level surface. As a mountain range, the Laramie arch, had almost disappeared at this stage. While the land retained this monotonous topography, the streams were sluggish and hence too weak to cut down into the surface. Meanwhile water from the occasional rains percolated down along the cracks and pores in the granite and slowly decomposed some of its constituent minerals.

Hornblende seems to have been the mineral most easily affected under these conditions, and hence was the first to decay. Its removal left the rest of the granite, consisting of big feldspar crystals and quartz, in a crumbling condition. As the streams were too weak to carry away the loose material thus constantly being formed, the blanket of crumbled



(*Fig. 2. The grassy upland near Buford, Wyoming.*)

granite remained in place, and, while the process went on, it slowly increased in depth.

Eventually, in consequence of a re-arching of the old Laramie uplift, the gradients of the streams were notably increased. They then became more effective in scouring out their channels and so began to sink trenches into the surface of the raised plain. The present result is the system of canyons in which the streams of the Sherman district flow.

Near the canyons the decayed and friable part of the granite has been removed, while the streams have cut down into the solid rock to a depth of 100 to 400 feet. Yet on the flat divides, which are merely remnants of the old raised lowland, the soil and rubble still remain. On one of these table-lands the Union Pacific Company discovered the material which it now uses so extensively and which is probably not excelled for road ballast by any other natural gravel in the country.

Doubtless it is equally good for concrete or macadam, where there are demands for it.

In this connection it may be interesting to inquire where other deposits of this nature may be found. Only actual exploration can answer this question definitely, but a little analysis will go far toward limiting the field of search.

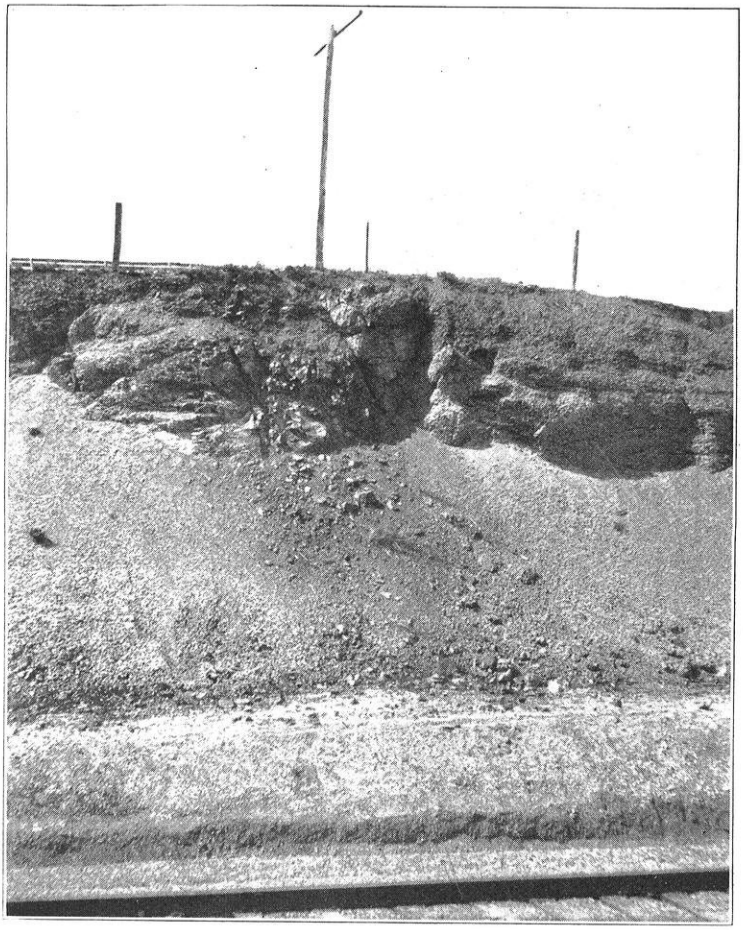
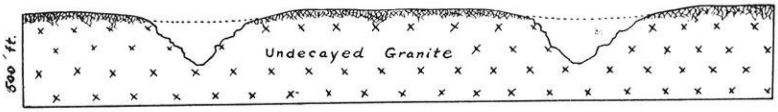


Fig. 3. Side of a railroad cut in the deeply rotted granite near Sherman, Wyoming. Shows a basalt dike cutting the original granite with slopes of loose gravel from both.)

It would be useless to seek material of this kind in any region where the rocks at the surface have not been subject to decay through a long period of time. For this reason it is improbable that any will be found within the glaciated area of Canada and northern United States, where the ice has recently scraped off the decayed surface rocks.

There would be scarcely more prospect of success in a region where the processes of decay are notably different



(Fig. 4. Diagram showing the decayed granite remaining on the ridges.

from those in the Sherman uplift. In warm humid regions for example, where the forest cover is thick, chemical decomposition proceeds farther than in the case described. Not only the hornblende decays but also the feldspar. The result is then not coarse gravel or rubble, consisting of hard angular pieces, but an earthy material mixed with grains of the refractory quartz. The conditions for this more complete decay are to be found especially from Pennsylvania southwest to Georgia, and on the Pacific slope in Washington and Oregon.

Another essential condition is that the decayed portion shall not be removed. Thus rugged mountains and canyon sides are unfavorable places; for erosion is rapid there, and usually keeps pace with decay. For this reason there is no accumulation of debris. Only where the surface is flat or gently undulating should we expect to discover thick deposits of rotted rock like those at Buford.

The character of the rock itself is another important factor. The excellence of the gravel at Buford is due to the large size of its hard feldspar crystals. A granite of finer texture would yield sand rather than gravel, while a rock poor in feldspar would be liable to more thorough decomposition and hence would produce sandy loam rather rubble.

From this analysis it is reasonable to expect that feldspathic gravel of the Buford type will be found only in the drier parts of the country, outside of the glaciated area, and even then only where a coarse-grained feldspathic rock is exposed in gentle slopes. In the United States these conditions are likely to be realized only in central Texas, and in small areas scattered here and there from Montana south and southwest to Mexico.

PRACTICAL RAILWAY TRACK WORK.*

K. L. VAN AUKEN.

This paper is written as a result of experience gained by the writer on railway track work during a period of about four years, a portion of the time as foreman in responsible charge. The subject will be discussed under three heads, viz: (1) Double tracking. (2) Relaying track. (3) Switch work.

Double Tracking.

By the term double tracking is meant the construction of a new track parallel to a track which has been in use for some time.

In doing any kind of track work with common laborers, the organization or distribution of the men is a matter requiring careful consideration and close attention, for it is the proper disposal of men which more than any other one thing affects the amount and quantity of work done. It has been said with truth that a gang of poor laborers well organized is a better gang and will accomplish more than a gang of good laborers poorly organized. Time and confusion are saved also by assigning each man his task, and requiring him to remain as he is placed until orders are changed.

The proper disposal of men means also that each man is placed on the kind of work for which he is best fitted and to which he is most accustomed. Men of great strength are not necessarily required, for a man of less than ordinary strength who is intelligent and active can accomplish more than a much stronger man, if the latter is less expert or is awkward.

Next to the organization, the amount of work accomplished by a gang will depend of course on the amount of

* Double tracking and relaying track are considered in this article. Switch work will be treated in another issue.—*Editor*.

work accomplished by the individual men. In one way or another the foreman should attempt to get the maximum from each laborer. To this end the foreman should consider the class of laborers employed as to general characteristics or traits, and the individuality of each man as far as possible. In this way he should be able to accomplish work of good quality and quantity. The greatest amount of work will be obtained from most gangs by treating them considerately. If such is the case, the work becomes more pleasant for both laborer and foreman. "Driving" men has been done away with to a large extent on the railroads, as it has been found in recent years that laborers of any class will not work under that condition. Since labor has become rather scarce the railroads, as well as other corporations, have been forced to adopt other methods for accomplishing work.

The building of a second track is much more simple than extending a track over a new line. In the first case the track already laid may be used for distributing material, while in building a new line the material must be handled on the track which is under construction.

After a grade has been completed and the ties lined and spaced approximately on the grade, a gang of forty-six laborers might be distributed as follows, starting at the head end of gang:

Tie fiddler	1	Spike and bolt peddler	1
Tie spacers	2	Spikers	12
Steel gang	12	Tie nippers	6
Rail nipper	1	Back bolters	2
Strap hangers	2	Tool man	1
Strap tighteners	2	Water boy	1
Rail liner	1	Assistant foreman	1
Joint plate peddler	1	Foreman	1

This distribution of laborers would be subject to small changes depending on class, size, weight and kind of material, and other circumstances.

The tie "fiddler" is provided with a "fiddle," i. e., a board about six inches wide which has a cleat nailed on it at right angles to the length of the board, the distance from the end of the board to the inside edge of the cleat being the standard distance for the end of a tie from the outside base of the rail. The board is held with the cleat securely against the end of the tie and a mark made on the tie along the uncleated end of the fiddle. The outside spike should be driven on this line, the outside base of rail thus coinciding with the mark. Before marking a tie the fiddler must examine it and make sure the "right side," i. e., the "bark side" is upward.

Behind the tie fiddler and just ahead of the rail gang are two tie "spacers." They are provided with a rod of the same length as the rail to be laid; the proper spaces center to center for ties under one rail-length are marked off on the rod. This rod is laid on the ground on the line side of the track, with the end opposite the end of the last rail laid. Each man drives a pick into the end of a tie and pulls the center of the tie to the mark on the rod. A tie line is stretched and the man on the line side must line the ties to it, while the man on the gage side must place his end of the tie so that the tie lies square across the track. The spacers must space ties for a full rail-length while the steel gang is setting up two rails. Four tie spacers could be used advantageously in some cases, as it is important that the rail gang be not delayed. The spacers must also inspect the ties which fall under a rail joint and if they are deficient in size or quality, they should be exchanged for ties of better grade.

The rail gang (commonly called "rust eaters") picks up the rail, sets the rear end on the ties, at the same time "entering" or inserting the rail into the angle-bars hung on the rail previously laid, the angle-bars having been tightened sufficiently to just allow the web of the rail to run between them. The head end of the rail is dropped at a word from the "heeler," the man who issues commands in the handling of each rail, and this movement throws the rail into its proper position in the anglebars. The heeler now gives the command "heel," and the rail is pulled backward against the other rail or against an expansion shim inserted between the end of the two rails.

In order to facilitate placing the rail in its proper position in the angle-bars, the end of the rail previously laid is raised a few inches by a "nipper" provided with a pinch bar.

The "strap hangers" are provided with short handled wrenches, these being handier and permitting faster work than wrenches with long handles. The latter are not necessary as the strappers are only required to start the nuts and not to tighten them. As soon as a rail is laid the strapper "hangs" a pair of angle-bars on the head end of the rail, fastening them loosely with one bolt. As the next rail is heeled into place he puts in a second bolt through the rail being placed, and after giving the nut a few rapid turns passes on to the next joint. Two bolt tighteners follow and tighten the nuts which the strappers have started.

The rail liner moves the line rail with a bar until it coincides approximately with the fiddled marks on the ties. If the ties have been properly lined scarcely any of them will have to be moved by the spikers and the finished track will be very nearly in correct alignment. The liner carries also a light wooden gage and throws the opposite rail approximately to gage; if this method is used no extra nipper is required with the gage spikers as is generally the case.

The joint plate peddler places the joint plates in the proper position for spiking. The spike and bolt peddler distributes four spikes for each tie and enough bolts and nut locks at each joint to finish bolting in full.

The spikers work in pairs and with each pair is a nipper. The nipper raises the tie up against the base of the rail with the nipping bar, using as a heel the "nipping block." When the nipper has the tie securely against the base of the rail, the spikers spike the tie. From the distribution of laborers given above it will be seen that six gangs of spikers are provided. Three gangs work on each side of the track, each gang spiking every third tie, i. e., the first gang spikes a tie and "drops" or skips two ties which the two remaining gangs spike. The rail when spiked must have solid bearing over the entire face of the tie. If the face of the tie is not a plane, the gage spikers must adze off the tie-surface beneath to fit the rail. By the above method the track behind the last gang of spikers is completely spiked, and this arrangement has two great advantages over the older method in which each gang started at a rail-joint and spiked one rail length in full, viz: (1) Twelve or sixteen spikers can be kept working in a distance of sixty feet which allows easy supervision by the foreman. In the other method the same number of spikers might be scattered over two or three hundred feet of track. (2) Each spiker must do as much work as any other for they are spiking tie for tie. It is then easy to discern a lazy or an incompetent man. By putting the best gangs of spikers in the lead on each side of the track and requiring the rear gangs to keep up with them, a greater amount of work can be done than is possible under the other method unless the gang is composed wholly of first class men, a condition which has very seldom or never been realized.

The back bolters bolt the joints in full and twist each nut as tightly as possible. Back bolting requires little skill and only ordinary strength; this is a good place to start in green or inexperienced men.

One of the most important men on the gang is the tool man. If he is selected with care he may relieve the foreman of a great deal of work. He is held responsible for the number of tools on the work each day, and also for the tools in the tool boxes. The condition of tools is left entirely to him; in case any are in bad order it is his business to exchange them for good tools at the tool house; if such tools are not to be had he must use his own ingenuity either in repairing those on hand or in "borrowing" from the supply of another gang. Although little hard work is required of a tool man, the choice of an industrious and intelligent man is advisable.

The assistant foreman has charge only of the rail gang and the strappers, unless he is able to run far ahead of the rest of gang; the setting up of rail will then be discontinued and the rail gang will be organized into spikers and bolters. The assistant foreman is held responsible for proper expansion in the track; the latter is accomplished by the use of shims which are inserted at each joint. If track is being laid with square joints the assistant foreman carries a long, wooden "rail-square," which he lays across the track at every third or fourth joint and determines whether or not one side of the track is running ahead of the other. In case the joints are not square, the longest rails must all be laid on the short side until joints again become square. A fact not generally known is that rails of ostensibly the same length will vary as much as three-fourths of an inch. Rails must therefore be measured carefully with a wooden rod or steel tape, and the longer ones marked before they are ready to be laid in track.

Expansion shims of various thicknesses are provided for laying track at different temperatures. It is not the temperature of the air which should be taken into account, but that of the steel itself. The temperature may be determined with sufficient accuracy by feeling of the rail with the bare hand. If the sub-grade is rough and uneven an allowance should be made for this condition, as the track will be shortened when it is surfaced. The track laid should be freed from all short kinks at the end of each day to prevent shortening. The rail laid in one day will move ahead, but if lining is neglected for several days the weight of track ahead is too great to be moved, and then when track is lined the rails will move in the angle-bars and take up the expansion.

The foreman is held responsible for the quantity and quality of work done by the gang. This includes the work done by the assistant foreman whether or not the foreman himself is present. It is the foreman who first organizes the gang, and he must be ready at any time to make changes dependent on the absence of from one to ten laborers. If a number of men quit at the same time and new men are not available, practically the whole gang will be disorganized and must be reorganized in a manner consistent with the decreased number of men. As the assistant foreman's time is constantly occupied ahead, the foreman must supervise the spiking and back bolting as well as inspect the kind of work his assistant is doing. Spikes should be driven perpendicular and always on the same edge of a tie. If a tie is properly spiked the outside spikes will *both* be ahead on the tie and the inside spike back, or vice versa. Ties should lie square across the track after they are spiked. Since the foreman is responsible for the assistant foreman's work, it is obviously necessary for him to pick out for this position a man who is both capable and willing to do his work properly. If the assistant foreman is sent out by a superior, and after a fair trial is found to be incompetent, it is a case of necessity for the foreman to discharge him.

A foreman should turn the characteristics of each man to the best advantage. Some men will do the most work when treated as equals, while others have little respect for a foreman who takes this attitude. A gang generally accomplishes more and better work when they are treated in such a way as to keep them in good humor. A man that is very talkative and attracts the attention of other men frequently, should be discharged. It is advisable to adopt methods which will make the least demand upon the strength of the men, provided such methods do not militate against the quality and rapidity of the work. Men who are treated as leniently as possible, and who see that the foreman is disposed to make the work as easy for them as practicable, require as a rule less supervision in order to have work properly done.

In organizing and handling any kind of a gang, the men should be kept as close together as possible, but not near enough to interfere with each other. One example of such organization is shown in the disposal of spikers mentioned above; that method is also good in that it supplies a standard by which to measure the work and the ability of the individuals. The closer the men are placed, the easier it is to oversee the work. The ingenuity or lack of ingenuity of a foreman is shown frequently by the bunched or scattered distribution of the men, as it is frequently quite difficult to arrange work so the gang can be kept compact.

Relaying Track.

Relaying track differs essentially from laying new track, in the following ways: (1) The old rail must be locsened and thrown off the ties before a new rail can be placed. (2) The ties are already distributed and imbedded in the ballast, thus presenting a smoother surface for the rail than ties lying on a new grade. (3) Every tie must be carefully adzed where the base of the new rail is to lie. This is necessary since the old rail has cut into the ties, and also because the new rail is heavier and has a broader base than the old rail. If many heavy trains pass, a groove from one-half to one inch deep might be cut into a tie before it would be worn out. (4) Relaying is generally done "under traffic," i. e., between the schedule time of regular trains. The time available is very limited in many cases.

The successive steps in relaying must be accomplished expeditiously and the gang should be so organized that the gap between unspiked old rail and the new rail be as short as possible, say not to exceed 150 feet, and the new rail should be spiked safe for traffic as soon as it is placed.

Since the time during which the track may be used for the actual work of relaying is limited, everything possible should be done beforehand that will reduce or expedite the work to be done after the track is cut.

Two general methods have been used for relaying as follows: (1) A string of rails as long as can be laid in the time available are bolted together on the outer ends of the ties before the track is cut. When traffic allows, the spikes are drawn from the old rails and these are lifted over the new rail and thrown off the ties by the liners. The new rail is thrown in place by a second lining gang, and then spiked. The old rail is thrown out in one long string, and the joints disconnected at leisure. (2) The old rail is thrown off the ties and the new rail set up one at a time by the rail gang, then bolted and spiked. In the first method are two disadvantages, viz: (a) Proper expansion and square joints can not be secured. (b) Ballast is sometimes carried in between the ties and the rail, preventing a solid bearing of rail on ties. The first method has the advantage of holding the track "open" for a somewhat shorter time, but the amount of preliminary work is greatly increased. The second method does not possess the disadvantages mentioned above, and produces much better track. The latter method seems to be coming into the more general use, and it will be discussed herein.

At times during the day when the track can not be torn up, the gang is divided into two sections. One section is sent ahead with claw-bars and adzes. On the inside of one rail and on the outside of the opposite rail, all the spikes are pulled except from every third or fourth tie, on which no spikes are pulled. The tie which is left spiked must have spikes on the outside of each rail in order to prevent the track from spreading. If the ties are not left thus the only force holding the track to gage is the resistance of the movement of the ties in the ballast. Failure to comply with this last rule has caused some bad wrecks on curves by spreading of the track. All spikes should be removed from joint-slots as they are frequently very hard to pull, and cause great delay if left till the rails are being thrown out. With this first section are two men with spike-punch and spike-maul, who drive all spike stubs protruding above the surface of the ties. One full row of spikes (except at joints) will be left in the ties on each side of the track. One side of the base of the new rail is slid under this row of old spikes, leaving spikes to be driven on only one side of each rail. The number of spiked ties per rail length which must be left to insure safe traffic depends on the flexibility of the rails, soundness of ties, alignment of track, and tightness or lack of expansion of track. The adzes with this first section are used to cut off the shoulder of the tie next to the rail on the same side on which the spikes are pulled.

The other section of the gang "joints up" the track previously laid, i. e., they move the ties to fit the spike-slots at the joints. In order to move these ties the ballast between them must be removed and the spikes must be pulled from them. No wide spaces should be left between ties, and generally four ties must be moved at each joint to even up the spacing.

At the time of actual laying of the rail the gang could be organized as follows, subject to variations similar to those mentioned in double tracking.

Flagmen	2	Expansion shim man	1
Head spike-pullers	6	Strap hangers	2
Hammer men	2	Bolt tighteners	4
Head liners	6	Spikers	6
Head adzers	6	Back liners	2
Back spike-pullers	1	Tool man	1
Back adzers	2	Assistant foremen	2
Steel gang	12	Foreman	1

The gang is split in halves, each half working on opposite sides of the track, with the exception of the steel gang and the head lining gang; these perform their work on both sides of the track.

The spike-pullers draw all the spikes left in the preliminary work on the loosened side of each rail. The two hammer men drive the claw-bars under the heads of those spikes which the bars can not grip unaided. If first class claw-bars are furnished, fairly expert men will seldom need the assistance of the hammer men. If, on the other hand, poor claw-bars only are available, six hammer men may be required instead of two, and even then the spike-pulling would probably be done much more slowly.

The liners throw the old string of rail off the ties on either side. One or two men using pinch-bars raise the side of the rail from which the spikes have been pulled, making it easy to throw the rail out of its former position. On the side of the track from which the inside row of spikes were removed, the rail must first be moved in to get the base of the rail from under the row of spikes, and then lifted over the row of spikes to get it off the ties.

After the old rail is removed the head adzers complete the adzing begun in the preliminary work. Lack of proper adzing will cause the rail to be tipped slightly after it is laid. In case the rail tips outward this defect tends to become worse with use. Both rails of the finished track should be perpendicular and show a wheel-bearing across the entire ball after the passage of trains.

A back spike-puller and two back adzers follow the liners. These men pull all the spikes and adze a wide bearing on the two ties on which the new joint will fall. It is generally easy to determine these two ties one rail length in advance of the steel gang by counting off the number of ties per rail in the track. It is necessary to produce a wider planed surface at the joints and to pull the spikes on both sides because the angle-bars protrude from one-half to one inch beyond the base of the rail. These old spikes would otherwise rest against the angle-bars instead of against the base of rail which is in their true line. Spikes which were formerly in the old track joints must be pulled because they are not in true line, and would not touch the base of the rail if the rail was in correct line.

The entering of the rail into the angle-bars is simpler than in laying track on a new grade, on account of the level surface of the face of the ties. The rail gang sets the rail within four or five inches of the row of spikes, and with one movement slides the rail backward into the angle-bars and sideways under the row of old spikes.

The work of the strap-hangers and bolters is the same as in double tracking, except that the work of the strap-hanger is easier and requires little ingenuity.

Few spikers are needed because at the time track is being laid only about four or five ties are spiked per rail length, and these only on one side of the raii because use is made of the old spikes on the opposite side. In contrast to most other track work the spikers in this case work singly instead of in pairs. If the track does not gage when the rails are placed against the old spikes, it should be gaged at the time of laying. Frequently where time is very limited, the gage rail is spiked temporarily against the old spikes and gaged later by a small gang, which keeps the track safe for traffic at all times. If the gage is to be widened that rail must be used as the gage rail on which the adzing was performed on the outside, regardless of what was originally the gage- or line-side of the track. If the gage is to be made narrower, the opposite rail must be used as the gage rail. All relayed track should be surfaced and lined after laying; therefore it makes little difference which side of the track is used as the line-side while relaying. Where "base plates," i. e. joint-plates, are used, the track *must* be surfaced after relay ing; this is necessary because the new joints will be too high, and the ties where the old base-plates were, will be too low. These joint ties will be too low or too high an amount equal to the thickness of the base-plates. Failure to surface the track shortly after it is relayed will allow rails to become surface-bent and injured.

One assistant foreman has charge of the rail gang, and a second assistant is required to oversee the work of throwing the old rail off the ties. Care must be exercised to prevent some of the ties being caught on the rail by a protruding spike-stub, an inadequately adzed shoulder, or by the binding of the spike head on the opposite side of the rail. Such ties would be dragged out of line and surface.

The tool man follows the gang shoving the "push-car" or truck on the track. He removes the expansion shims at a distance not less than six rail lengths behind the steel gang, and loads these together with stray tools and light track material on the car. If expansion shims are removed nearer than about six rail lengths from where the steel is being set up, the rails will be driven backwards by the rail gang as they "buck" or slide the rails against the end of the rails already laid; in this way the expansion would be destroyed. On the push-car are also a pair of switch points to be used in making temporary track connections.

The foreman must properly protect the track by sending out flagmen. He must arrange the amount of work attempted so as to have the track ready for all regular trains. The work should progress in a manner such as to cause no greater delay than about fifteen minutes to "extras," i. e., unscheduled trains. These duties he has in addition to those of a track foreman on double track work.

To make a temporary track connection, a joint in the old rail is broken and the switch points are used in the gap formed. The points should if possible be put in the "trailing," i. e., the wheels should pass over the heel of the point first; otherwise there is danger that a sharp flange may force its way between the point and the track and thus cause a derailment. It is not possible to put in trailing points on single track where the traffic runs in both directions for the trains running from one direction or the other would hit the connection "point on." A screw clamp has been designed which holds the point rigidly against the rail; these should always be provided where points are put in single track as a temporary connection.

All track laid at one time should be jointed up before a new piece is laid. If this is not done the rail may "run," causing the expansion to be distributed unevenly. Some joints will be opened up wide and battered by trains. Such joints are extremely difficult to keep in surface.

It is very essential that laborers work rapidly during the time the rail is being laid. By allowing the gang a short rest after the track was again connected, an increase of twenty-five per cent. was effected in one case.

A relaying gang should number not less than sixty men at all times. The number of laborers is much more important here than in double tracking, because a track being relaid must be in condition for trains the greater part of the time, while in double tracking trains are not run on the part directly under construction. A gang too small to permit the disposing of a sufficient number of laborers on each detail, will accomplish less work per man, and the work is made more arduous and more difficult for both laborers and foreman.

If in any case one detail of the work drags, the number of men on that portion of the work should be increased or better men substituted. It is a good plan to have it understood that the man who shirks will be placed on some other detail which is unpopular; the rail gang is a place not liked by most men on account of the heavy lifting. The work of the whole gang should not be decreased by delay on account of a few men.

THE GUNNISON TUNNEL.

FRANK A. NEWTON.

Driving Heading No. 4.

The Gunnison Tunnel is the most salient feature of the irrigation system known as the Uncompahgre Valley Project. This project is one of the many undertakings of a like nature now being carried on in the arid regions of the west, by the United States Reclamation Service. The Uncompahgre Valley is located in Southwestern Colorado, lying in the counties of Montrose and Delta. The valley is bounded on the north and east by a long, rugged range of foot-hills known as Vernal Mesa. This range rises about 2,500 feet above the valley, having its greatest elevation at the eastern end and sinking into the valley at its western end. Volcanic action has split this range from end to end, forming the Gunnison Canyon through which the Gunnison River flows. In order to divert the water from this river for irrigation purposes in the valley, it is necessary to pierce the range, and this requires a tunnel nearly six miles in length.

The contractors established camps at both portals, and began excavation on headings 1 and 4, early in 1905. It had been expected that when the elevation of the tunnel was reached at heading 4, the material to be excavated would be found to consist of the shale which underlies the surface throughout this region. This shale strata, for some reason, was lower here than at other points nearby, and the tunnel was opened in hard, compact adobe. As may be seen in the profile, this section of the tunnel lay in the valley, and the material to be excavated was in reality "made ground." Parts of trees were found 80 to 100 feet under the surface. The ground soon became looser, containing streaks of gravel and sand and many large boulders. Large flows of water added greatly to the difficulties of excavation, and made the ground very dangerous and hard to hold. No blasting could be done, and all excavation was accomplished with picks and mattocks. The nature of the ground in this heading, gave to it the name of "mud tunnel," and it was always referred to by this title.

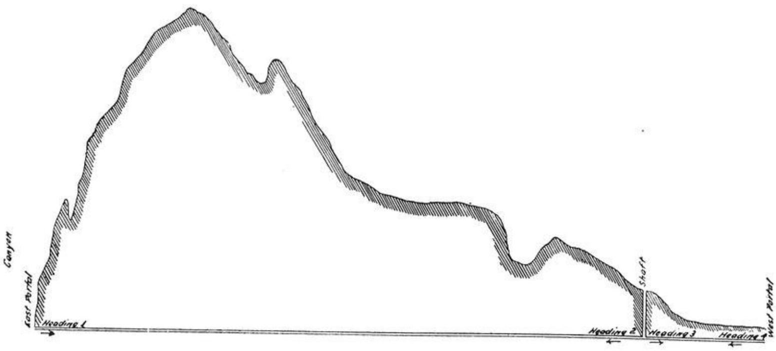


Fig. 1.

The contractors used the under-cut system in driving the mud tunnel. This system consists essentially of a smaller tunnel or drift, driven in the lower half of the tunnel section. The floor of this drift coincided with the grade of the completed tunnel, and the track laid in the drift was used when the section was enlarged to its full size, without moving it in any manner.

It will be necessary, in order to describe this method, to refer often to the cross-section of the tunnel, Fig. 2. The drift mentioned above is the section marked A on the drawing, enclosed in the first excavation line. The dimensions are 5 to 6 feet wide and about 8 feet in height, large enough to permit the use of horses or mules to haul the muck cars. As fast as the excavation proceeded pony sets were erected. These sets consisted of 8 by 8 inch timbers, lagged close on the top, and on the sides where necessary to hold the walls. The sets were placed 4 feet, center to center, and the posts were set on foot-blocks of 4 or 8 inch stuff. Several bad

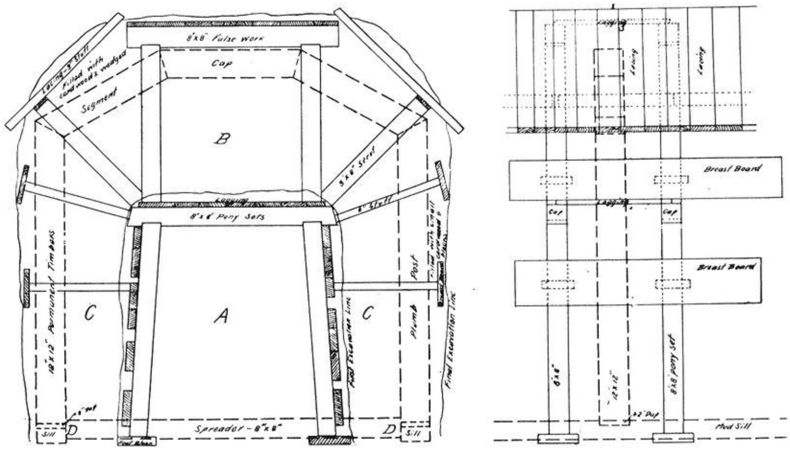


Fig. 2.

X Section of "Mud" Tunnel. Permanent timbers shown by heavy dash lines. Lagging around permanent sets not shown.

Side elevation. Showing Breast Boards and Lacing. Only ends of Structs are shown.

runs were the result of the attempts to carry the excavation more than a few feet in advance of the timbers.

After several hundred feet of the pony sets had been erected several gangs were put at work at scattered points along the drift. These gangs then began what is called the "brushing down." Taking out a few pieces of the lagging overhead, they worked their way upwards into the section marked B. The muck ran down into cars spotted directly under the opening. The false work of 8 by 8 inch timbers was then set up, care being taken to see that the caps of the false sets were high enough to clear the caps of the permanent sets which would follow. The uprights of the false sets were placed directly over the uprights of the pony sets below.

Each gang was then divided into two shifts, which worked away from each other, and along the line of the tunnel, setting up the false work as they progressed. Not only did they open up a drift in the upper half of the tunnel, as described, but they also excavated a space at each side, thereby completing the arch of the tunnel. The arch was maintained by the lacing shown in Fig. 2. This lacing consisted of 3 or 4 inch lagging, and formed a tight roof to prevent any runs from the back. It was held in place by the false work at the top, and by means of struts extending over to the pony sets at the lower ends.

While this overhead work was under way, another gang was working on the enlargement of the lower section. Taking out the lagging on the sides of the pony sets, they excavated to full section at C, working upward and catching the walls by means of breast boards braced across to the pony sets. This process was continued until the space opened by the men above was encountered. A trench was then dug at D and in the trench were laid 4 inch foot-blocks, set close together and at right angles to the tunnel line. The mud sills, 6 by 12 inch timbers, were then laid on these blocks. The length of the sills was necessarily a multiple of three, as the posts of the permanent sets were always set 3 feet, center to center. The lower end of these plumb posts were fixed in 2 inch caps cut in the sills, and they were also nailed to the sills with long drift bolts. After the posts of the permanent sets were in place, they were lagged close behind with 3 inch stuff, and the space between the lagging and the final excavation line was filled with muck and cordwood and tightly wedged. The caps and segments were slung into position on the posts, and the whole arch lagged and packed as was done behind the plumb posts. After a stretch of the permanent sets were in place, the pony sets were removed and the posts of the false work thrown down, the caps of this overhead work remaining above the permanent sets. On account of the great lateral pressure, it was found necessary to use spreaders in many places. As shown in Fig. 2, these spreaders ran across the tunnel, from post to post of the same set, serving to preserve the required width of the tunnel. The spreaders also served as sleepers for the track rails.

The contractors withdrew after they had driven about 800 feet of the mud tunnel, as they had encountered material much more difficult and expensive to handle than they had anticipated. The work since then, has been prosecuted under the direct charge and supervision of the engineers of the United State Reclamation Service. Believing that the under-cut system was unsafe and uneconomical in that ground, the officials decided to change to the crown bar system, and the remainder of the mud tunnel was driven by this method.

The crown bar system is diametrically opposed to the under-cut system, in that it consists of a drift driven in the upper half of the tunnel section rather than in the lower half. Furthermore, this drift was at no time driven more than 30 to 40 feet ahead of the permanent timbers.

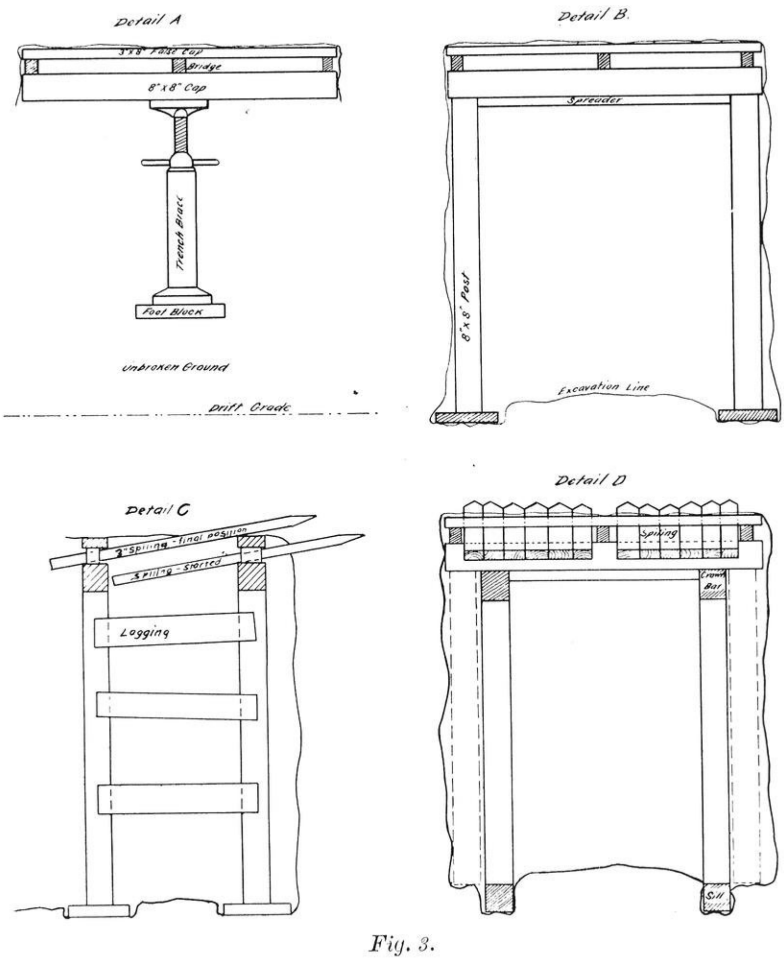


Fig. 3.

The drift was about 8 feet high, by 5 to 6 feet wide. The breast was broken down with pick and mattock, and at regular intervals of about 4 feet the roof or back was caught up in the manner shown in Detail A. A cap was thrown across the drift, this structure consisting of three parts, the false cap of 3 by 8 inch stuff, the bridge, and the 8 by 8 inch cap. The bridges were small blocks, and served only to separate the false cap and the 8 by 8 inch cap. The whole structure was held in place against the back by means of a trench brace, and wedged into position. With this set in place the heading men proceeded to pick out the ground on each side of the trench brace until the elevation of the drift floor was reached. Foot-blocks, 4 inch stuff, were laid, and 8 by 8 inch posts set upon them to hold the caps, and the trench brace was removed, the heading set appearing as in Detail B.

As the breast was broken down in advance of the set described, spiling (3 by 8 inch) were inserted between the false cap and the 8 by 8 inch cap, and driven ahead with a slight upward inclination. The posts of the spiling were always kept several inches ahead of the breast, and were always in unbroken ground, and served to form a roof which prevented falls from the back. Having opened up about 20 feet of drift in this manner, the crown bars and temporary sills were put in place. The crown bars used were either 8 by 8 inch timbers, or 12 by 12 inch timbers, depending on the nature of the ground to be held, and were generally 16 to 20 feet in length. The sills were always 8 by 8 inch timbers, and of the same length as the crown bars. A trench was excavated just inside of the posts of the drift sets, and the sills laid therein. Posts were set up on the sills, about 4 feet apart, and these uprights supported the crown bars, which in turn took the weight which was previously on the posts of the first drift sets. In Detail D a cross-section of the heading is shown which shows the crown bars and sills and the first drift sets in dash lines just outside of the posts set up on the sills. A side view of the crown bars and sills is given in Fig. 4. The

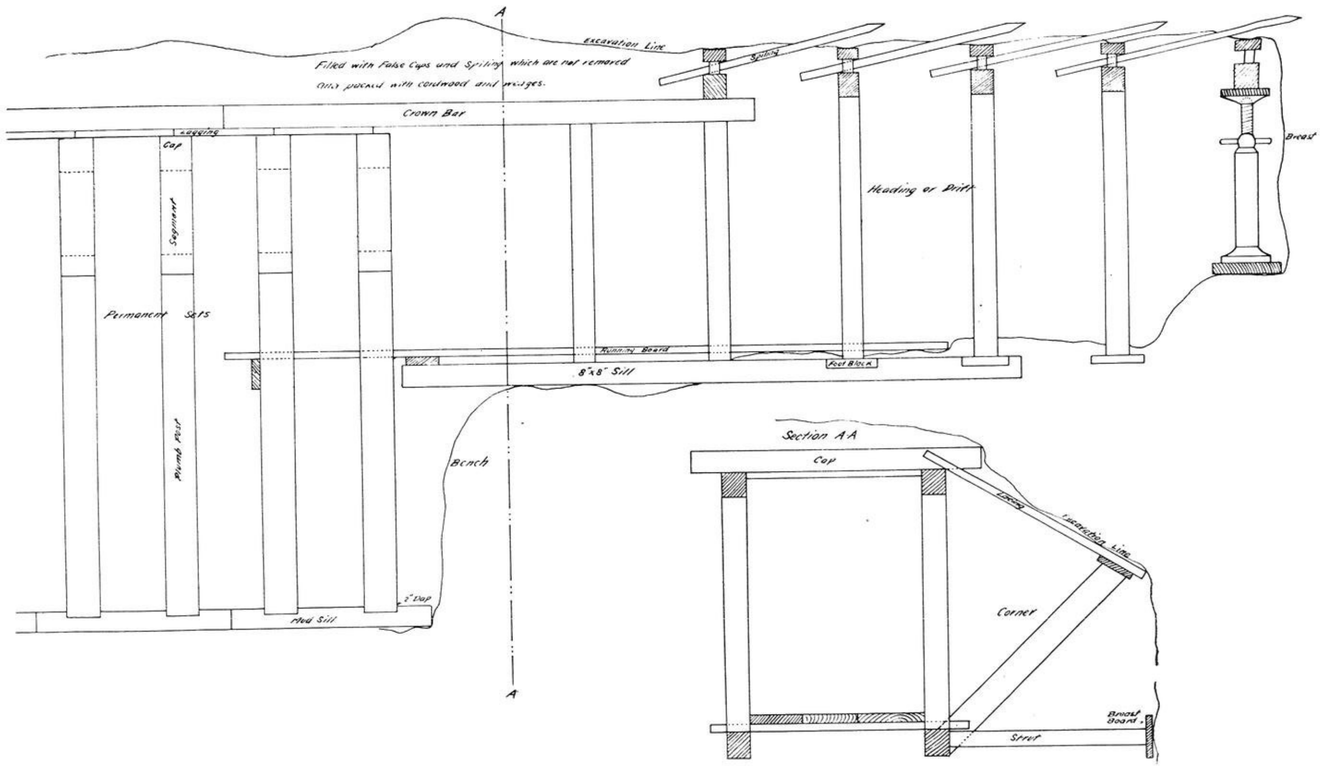

Excavation Line
Filled with False Caps and Spiling which are not removed
Only packed with cordwood and wedges.
Spiling
Crown Bar
Lagging
Cap
Segment
Permanent Sets
Plumb Post
Heading or Drift
Breast
Running Board
Foot Block
8"x8" Sill
2" Dap
Mud Sill
Bench
A
A
Section A-A
Cap
Lacing
Excavation Line
Corner
Breast Board.
Strut

Fig. 4.

posts of the first drift sets were removed after the new posts were erected. A spreader wedged into place, between the bars, and blocks in back of them, prevented any lateral movement.

A side view of the heading, showing all the stages of the work, from trench brace to permanent sets, is shown in Fig. 4. The crown bars are placed at such an elevation as to permit the caps of the permanent timbers to come just under them. The crown bars were not removed, but were left in position as shown. They constituted a part of the drift timbering, and also served to distribute any load which came upon the permanent, 12 by 12 inch timbers, thus preventing the concentration of any pressure from above on one or two of the permanent sets.

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EDITORIALS.

THE new University heating station, of which a complete description by Professor Thorkelson appeared in the last April number of the ENGINEER, has been completed for present purposes and is now supplying heat to the University. When entirely finished the plant will heat all of the University buildings. At present a separate plant heats the agricultural buildings. The old University heating plant is still maintained in operation for the purpose of supplying the heat and power that are used in the University shops. The new station now contains five Babcock & Wilcox boilers, which number is ultimately to be increased to twelve. The splendid opportunity which the new station affords for studying the efficiencies of boilers is already being taken advantage of by three seniors, Messrs. Drew, Ives and Rankin, who, for thesis work, are running tests on the plant. Two tests are to be run, one of which consists in making a complete commercial test on one boiler and in making temperature determinations at various points, and the other which consists in making a complete plant test of at least forty-eight honrs' duration. The new heating station is of especial interest to engineering students of the University in view of the fact that about it will be built the new engineering laboratories, shops, etc., which the future is to bring forth.

DURING the time of Dean Johnson's connection with the College of Engineering, several series of parties and lectures were given by the various classes in the Engineering Building. These became very popular. The last of the series given by the class of '03 culminated in a minstrel show and was given in Library Hall. This met with such approval that the class of '04 gave another minstrel show. The class of '06 not only showed that the minstrel idea idea was still alive, but staged a first class minstrel show in Library Hall. This performance is remembered by the present senior class as a very clever production and a decided minstrel hit.

The Engineering College has grown and the class parties are no longer practical, but the spirit of song and dance instilled by the class of '03 is felt, and will make itself manifest by the production by the senior class of a first class minstrel show, accompanied by the usual stunts. Due to the growth of interest in such undertakings, it has been found necessary to stage it in the Fuller Opera House.

The benefits derived from work of this nature cannot be estimated. The engineers are naturally a jolly set, and great lovers of music, and therefore the logical class to appear in a minstrel show, and there is no doubt but that they will maintain the high standard established by the former classes.

A committee consisting of Messrs. Moss, Drew, Henke, Coleman and Canfield have been appointed to make the necessary preliminary arrangements. Mr. Henke and Mr. Drew have been appointed as Musical Directors, Mr. Huels as Stage Manager, and Mr. Ordway as Manager.

A bulletin has recently been issued by the University of Wisconsin on "Current Practice in Steam Engine Design." The bulletin gives the results of an investigation by Ole N. Trooien for a thesis for the degree of Mechanical Engineer. It contains forty-two curves showing the relation between the dimensions of the various parts of a Corliss and high speed steam engine. Each curve shows the average, minimum and maximum ratios employed by the leading engine manufacturers. These results are of value not only to the designer, but to the purchaser in the selection of an engine.

ON Jan. 18 a lecture was given by Dr. James Douglas in the Auditorium of the Engineering Building on the relation of metallurgy to the sciences. Dr. Douglas gave a brief review of the development of the iron industry, and compared some of the old methods with those employed at the present time. He emphasized the fact that there is no sharp division between the various branches of science.

In the early furnaces coke was seldom used on account of the high draft required, which was then unattainable. Only half a century ago coke when employed was always mixed with charcoal. The process was very wasteful. This is illustrated by data taken from Washington's smelter. It required 6,400 tons of charcoal to produce 200 tons of pig iron. He used four square miles of forest per year, requiring many men and teams to keep the furnaces supplied with fuel. If the same methods were employed at the present time, it would require the whole population of the United States to supply fuel for the present output of our smelters. An old furnace could barely produce one ton of pig iron a day, while a modern furnace can produce six hundred tons per day. In Sweden only charcoal is used for smelting, to avoid any possibility of introducing sulphur. Swedish steel costs about $130 per ton.

The improvement in the economy of furnaces is due largely to the work of engineers and chemists. The mechanical engineer brought forth a new furnace and the chemist utilized the byproducts. The greatest waste at the present time is in the coke ovens. The lost energy from these is beginning to be utilized through the development of the high tension transmission lines.

The foreigners were the leaders in inventions on the furnace. Only one important invention is due to an American inventor. But when our engineers once get a hold of a foreign idea they develop it by the use of machinery so that they get more out of the idea than the foreigners. The introduction of machinery in the foreign countries is very slow, due to the sympathetic bonds existing between the employer and employee. Some instances are on record where a plant was moved to another town that they might introduce machinery without breaking traditional bonds.

Dr. Douglas predicted that the future will bring about the harnessing of the winds and tides. The 400,000,000 tons of coal used annually for moving our trains, turning our mills, smelting our ores, lighting and warming our houses will be replaced by the unused forces of nature which we know and others which we have not dreamed of. Advances far greater than those of the past are assured. We need not fear that our children will die of starvation; but we may look forward to international copartnership. And the inequalities which have caused discontent will be reduced.

PROF. R. L. SACKETT, of Purdue University, gave an interesting lecture on "Economics of Transportation" to the Engineers, Jan. 27. Prof. Sackett gave a brief review of the early canal construction in this country, and then confined his remarks to the Mississippi Valley. He called the attention to the resources of the valley and pointed out the need of water transportation, saying that fully twenty per cent. of the cost of manufactured products to us is represented by freight charges. At the present there is a need for greater transportation facilities. During the last decade the agricultural production of the Mississippi Valley has doubled, while during the same period of time the railroad mileage has increased only twenty-one per cent. The need of greater transportation facilities was clearly shown recently by the freight congestion which caused severe losses among the shippers. The necessary money to build the railroads to take care of this increasing demand for transportation is not to be had on account of the large amount tied up in industrial enterprises.

Wagon transportation costs from fifteen to twenty cents per ton-mile. The average rate of the Illinois Central for one year was seven mills per ton-mile; while the average on the Great Lakes was eight-tenths of a mill per ton-mile. The government has spent eighty million dollars on the improvement of the waterways and harbors on the Great Lakes. The money saved by the difference in cost of rail and water transportation on the Great Lakes amounts to three hundred twenty million dollars per year, or four times as much per year as the total amount spent on the improvements. Fifteen million dollars are invested in boats and barges on the Ohio River. Coal is carried from Pittsburg to New Orleans in barges at the rate of six-tenths of a mill per ton-mile. The water transportation season is very short due to low water, but the transportation companies make profit on their investment even though their capital is in use for but a short time. Plans are under way by which the maximum draft of six feet is to be increased to nine feet during drought. To accomplish this about forty dams are to be constructed between Pittsburg and Cairo at a cost of sixty-three million dollars. Thirty miles of this waterway has been constructed from Pittsburg. At present freight is shipped down stream only. On account of the difference between the products of the north and south there is a large demand in the north for southern products; consequently after the waterway is completed freight will be shipped both directions.

Bulky material which is to be shipped long distances is most economically transported by water. The waterways should carry the long distance freight and the railroads act as distributing agents. The barges on the Mississippi carry freight at a speed of about one hundred twenty miles per day; while the average travel of freight by rail is about twenty-five miles per day, including the time it is in the switch yards. After the Panama Canal is completed and the Mississippi River waterways developed so that the products of the central and western parts of the United States are cheaply transported, there will be a tendency for New Orleans to become the chief exporting city of the United States.

A preliminary bulletin on "The Significance of Drafts in Steam-Boiler Practice" is soon to be issued by the Technologic Branch of the United States Geological Survey. The authors of the bulletin, Walter T. Ray and Henry Kreisinger, in carrying out the particular work assigned to them in the general plan for the conservation of the fuel resources of the country have this to say in their bulletin:

"The experiments so far made seem to indicate that it is possible to double or treble the capacity of a plant without making any radical changes in the furnaces and boilers. These increases require about double and treble the quantities of air to be put through the fuel beds and boilers. It also seems probable that rebaffling the boilers will often permit the capacity to be doubled or trebled, while still getting more steam than formerly per pound of coal for uses outside the boiler-room.

"These experiments were undertaken with the object of clarifying ideas concerning the passage of air through fuel beds and boilers. Measured weights of air were passed through two beds of lead shot, in series, one of which remained always the same and represented a boiler; the other being varied as to size of shot and depth of bed, and representing a fuel bed. Careful observations were made of the weight of air passing through the beds per minute. All data was plotted in many charts, so as to permit the study of them from several points of view. A number of laws were deduced bearing on the relative amounts of power required to force air through fuel beds of various thicknesses composed of various sizes of coal, and through boilers of various length and area of gas passages.

"An important part of the discussion relates to an increase in the capacity of boilers by increasing the amounts of power which must be applied to pressure and exhausting fans in order to force several times as much air through the fuel beds and boilers.

"It may be possible, as a result of these investigations, to raise the rate of working the boiler heating surface to three or even four times its present value. Such an increase would undoubtedly mean new designs of grates, stokers, furnaces, and boilers, especially fitted for high rates of working. Fan equipments designed to supply three or four times as much air under several times the pressure would be provided with more efficient engines, which is an additional factor favoring high-capacity working.

"It must be borne in mind, as stated above, that the results are tentative. It will cost money to force gases at high speeds through fuel beds and boilers, and there will soon be pressing need of such quantitative data as will enable the largest possible part of the energy imparted by the fans to be advantageously utilized.

"The attempt must not be made to put more air through existing boilers by running the fans a great deal faster, because the power consumed will increase far faster than the above calculations estimate. New fans and engines must usually be installed of sufficiently larger size to supply the larger quantities of air at as high an efficiency, if not higher.

"As has already been suggested, one way of reducing the work required from the fan in the case of doubling the capacity of the boiler is to increase the grate surface, so as to avoid a high increase of pressure drop through the fuel bed, increasing materially only the pressure drop through the boiler proper. A low pressure drop through the fuel bed would also insure better combustion of the fine particles of coal which would be carried out of the stack unburned if high gas velocities through the fuel bed were employed, the high velocities being obtained by high pressure drops. This last method is being successfully used by H. G. Stott and W. S. Findley, of the Interborough Rapid Transit Company, New City. They have recently installed an extra Roney stoker under the rear end of each of several Babcock & Wilcox boilers, with the result that the amount of steam produced was nealy doubled, the combined efficiency of the boiler and furnace dropping only about 3 per cent. A complete description of the outfits and the results is given in a paper read by Walter S. Findley, Jr., before the American Institute of Electrical Engineers in December, 1907. In this case the pressure drop through the fuel bed was the same as with the single stock, or perhaps decreased slightly. Of course, the pressure drop through the boiler proper increased considerably. An electrical engineer would say that the above experimenters put two fuel beds in parallel and with the same potential drop obtained twice the current (weight of gases). The same result could have been obtained by thickening somewhat the fuel bed on the single stoker and increasing the pressure drop through it, in which case the electrical engineer would say that the experimenters put two fuel beds in series and by increasing the drop of potential obtained twice the current (twice the weight of gases). The method of increasing the grate area is a promising one, because it requires less work from the fans; it is especially to be preferred in those cases where there is a high percentage of slack in the coal, as already explained.

"'The figures and principles derived from the experiments and tests presented in this bulletin may not be applicable directly to special problems; they suggest methods by which each problem can be studied and its successful solution brought about. Further experiments with laboratory apparatus as well as with hot fuel beds are desirable before more accurate figures can be given. The Geological Survey contemplates the making of such experiments in the near future, the results to be worked up and published in the next bulletin on 'Drafts.'"

ENGINEERING SOCIETIES.

U. W. Engineers' Club.

Since the last issue of THE WISCONSIN ENGINEER, the U. W. Engineers' Club has been exceedingly progressive. Many very desirable underclassmen have been initiated. The talks have been given by professors, instructors, and members of the club.

On Dec. 4, Mr. C. I. Zimmerman, '03, former member of the Club, spoke on hydro-electric power development at Niagara Falls. The location, operation, and earnings of the present installations were explained in detail. It was made very evident that, with but an average earning of 4 per cent. there was no great bonanza for these corporations. The total power available is 3,500,000 H. P. With 13 tons of coal per electrical horse-power year, with cost at $2.50 per ton, it was clearly shown that it cost the United States and Canada one hundred million dollars per year to run the Niagara Falls. Mr. Zimmerman was very decidedly of the opinion that the total potential energy of the Falls should, in time, be developed.

New methods employed in laboratories and industrial works for the measurement and recording of high temperatures were discussed by Mr. Witt. He explained the construction and working of the platinum thermometer as a direct reading instrument, and how when connected to a callender recorder, it gave a continuous record of heat conditions in a furnace. The advantages of a thermocouple connected to a galvanometer or a recording milli-voltmeters were also discussed. It was shown how very high temperatures like that of the arc or Nernst glowers could be measured by means of the Fery radiation pyrometer or with optical pyrometers.

H. J. Newman presented a humorous discussion of the fourth dimension. He based his proof of its existence, chiefly upon the optical properties of the tetrahedral carbon atom.

Mr. J. R. Shea explained the electrical and mechanical principles evolved in the design and construction of the ordinary commercial lifting magnet. He showed the enormous savings which it has effected for the steel industry.

Mr. J. E. Love who for some time has been employed in the Bureau of Standards at Washington, D. C., gave a highly instructive talk of that branch of the Department of Commerce and Labor. The researches and calibrations in electrical engineering received special attention.

The Milwaukee Telephone Exchange and its connections with the north, east, and south divisions were explained by W. J. Dittmar. One fact mentioned was how, when the grand central was inaugurated, all the lines were transferred between 10 P. M. and 5 A. M.

Mr. I. H. Spoor, G. L. Johnson, and C. N. Johnson, presented interesting and instructive topics before the club, January 8. Mr. Spoor explained the mechanical principles involved in door manufacturing machines, and discussed very thoroughly the process which the material went through before it was constructed into a door.

G. L. Johnson gave a paper on the electric furnace in modern industry. This paper demonstrated very clearly the progress that has been made in the manufacture of graphite, corborundum, calcium carbide, aluminum and high grades of steel.

C. N. Johnson gave a review of the progress which electrical industries have made within the last year. Facts and data presented proved concisely that the electrical industry was affected less than any other industry by the recent financial disturbance.

At a joint meeting with the C. E. Society, Prof. Thorkelson delivered a lecture upon the development of the steam locomotive. He showed that the steam locomotive, like all of the great inventions, is not the result of a few men's work, but is the work of generations of men. The lecture was greatly aided by the use of lantern slides, which gave views of a series of locomotives from the first down to the most modern type.

At the mid-year election, Dec. 18, '08, the following officers were chosen:

President—John R. Shea, '09.

Vice-President—Hale H. Hunner, '09.

Secretary and Treasurer—Robert L. Rote, '10.

Censor—L. Witt, '09.

Assistant Censor—Windfield J. Dittmar, '10.

Civil Engineering Society.

The meetings have been so well attended this year that it has been almost necessary at times, for lack of space in the regular society room, to adjourn to the auditorium. Moreover, the interest shown by most of the members, and their efforts toward making the meeting a success, have resulted in the presentation of a number of interesting and instructive addresses.

The material for many of these addresses is gathered from the personal experiences of the speakers. Most of the members have, at one time or another, been employed on engineering projects of some sort. They of necessity have become well acquainted with the details of at least that part of the work in which they were themselves engaged, and have generally also become familiar with the principles and methods employed on the whole project. Their viewpoint is that of the engineering student, and hence their descriptions and explanations of the work include the solution of those vexatious though often simple problems that loom up so big to the beginner, but are forgotten by the more experienced men. Since the audience is composed of other students who probably will have the same problems to face some day, such a presentation is desirable.

Other addresses and papers are furnished by members who have reviewed some particular phase of engineering development, even though they were not actually engaged in the work. The speaker is then able to emphasize the important points and call to one's attention the main facts concerned, leaving a more accurate and more lasting impression than would the mere reading of an article in an engineering magazine.

A third source of material, which has not as yet been used, but which probably will be, later in the year, is the research work done by some of the seniors in connection with their theses. Doubtless many important facts have in the past been unearthed in this research work, and embalmed immediately thereafter in the library. These facts ought to be given at least one airing before they go to their final resting place, and the patient plodder that dug them up ought to be given at least one opportunity of thinking that it was after all worth while.

ALUMNI NOTES.

C. E. Carter, '04, has resigned his position as Superintendent of Distribution with the Madison Gas & Electric Company, and has accepted a similar position with the Northern Colorado Power Company at Denver, Colorado. Mr. Carter has been with the Madison Gas & Electric Company since his graduation, and has shown himself worthy of the promotions which placed him in the position he is now leaving. Last June Mr. Carter received a Degree in Electrical Engineering, and also was recently elected chairman of the Madison Branch of the American Institute of Electrical Engineers. Although Mr. Carter's cheerful face and pleasant "How are we?" will be missed in Madison, the ENGINEER wishes him success in his new position, and hopes he will find life "among the Indians" an enjoyable one.

E. H. Kifer, '08, the outside representative of the Madison Gas & Electric Company has been promoted to the position of Superintendent of Distribution recently vacated by Mr. Carter, resigned. As will be remembered Mr. Kifer was in the employ of the Madison Gas & Electric Company before graduation and at this time became thoroughly familiar with the present system of distribution. It would be hard to find another man who could fill this vacancy in as capable a manner as Mr. Kifer. It is seldom that one so recently graduated is promoted to a position of such importance and responsibility. Mr. Kifer is to be congratulated on the progress he has made since his graduation. This promotion is another demonstration of the fact that engineers of the later type are needed in all engineering work. In the Engineering Department of the Madison Gas & Electric Company are two technical men both of Wisconsin and of recent years. These men are D. A. Powell, '07, in the Gas Department, and E. H. Kifer, '08, in the Electric Department, and both fill important positions.

Mr. Powell has charge of the manufacture of the gas, and is chief chemist in the Gas Laboratory. Mr. Kifer is in direct charge of the electric light and power distribution.

Men of this caliber are a credit to the institution from which they graduate, and also help to uphold the high standard of the Engineering Department of the University.

Mr. Ernest A. Moritz, '04, formerly of Madison, but now located at Sunnyside, Wash., recently made a visit at his home, 1021 W. Johnson. Mr. Moritz, who was in the Mathematics Department at the University for several years, is now in the U. S. Reclamation Service, in the capacity of assistant engineer, doing work in the Yakima valley. He reports the Yakima valley all that it is represented to be as a wonderful fruit growing country.

Reed, '08, is now at Hamilton, Montana, employed by the Como Land Co.

E. P. Abbot, '08, who is in the employ of Chicago, Milwaukee & St. Paul Railway, is in the Engineering Department in the general office in Chicago. Mr. Abbot previous to the first of the year was in Montana as Superintendent of Construction of a concrete dam which is to be used for irrigation purposes. The difficulty of the work can be realized when it is considered that the dam is in the mountains, a long distance from any railroad and all the material used in its construction must be "packed."

S. W. Vanderzee, '08, is now at Houghton, Mich., and is an instructor in the School of Mines.

C. D. Purple, '03, employed for a number of years by the Oliver Mining Company, has been promoted to the position of chief engineer of a new district which has been created at Chisholm, Minn.

F. C. E. Wessel, '07, who is Superintendent of the Cheyenne Gas Works, Cheyenne, Wyoming, was in Madison for a few days at Christmas time. It is reported that Mr. Wessel came single and went away double. Congratulations, Wess.

E. L. Leasman, '07, resigned his position with the Corn Products Refinery Company, to accept the position of Superintendent of the French Battery Company of this city.