THE BELL-ELLIOTT TANGENT READING TACHEOMETER.

WE illustrate herewith a tacheometer theodolite, patented by Mr. G. J. Bell, of Carlisle, England. In order to measure distances with this instrument a level staff is erected at the distant point, and the instrument having been carefully leveled, two readings are taken on points of the staff, say 10 feet apart. Then, if θ be the inclination of the line of sight to the horizontal in making the upper reading, and ϕ the inclination in making the lower reading, we have obviously the horizontal distance of the staff:

$$H = \frac{10}{\tan \theta - \tan \phi}$$

In Mr. Bell's instrument a ready means is provided for reading off these tangents direct from the instrument, without referring to tables. Subtracting the two readings from each other, and multiplying the reciprocal of the result by 10, gives at once the horizontal distance. The instrument is essentially an ordinary theodolite fitted with a trough compass, which can be used in the ordinary way. The two attachments which fit it specially for tacheometry consist of, in the first place, a very accurately divided scale rigidly secured to the upper parallel plate, and fitted with a micrometer adjustment, by which it can be shifted with

London Engineering for the engraving and description.

THE USE OF GAS ENGINES FOR DYNAMO DRIVING.

By JOHN C. KELLEY.

I HAVE often been asked why it is that gas, gasoline, and oil engines are more largely used in England than in this country. For this condition of affairs various reasons may be given, the most obvious, perhaps, being that illuminating gas of, say, 700 heat units value costs about twice as much here as in England. For example, in Manchester, England, such gas costs about 60 cents per 1,000 cubic feet, while in New York city the present rate is \$1.15 per 1,000 cubic feet. The result is that when any comparison of cost per horse power per hour is made with an economical type of steam engine the figure, 2 cents per horse power hour, obtained with a gas engine of good design, is much less favorable to the gas engine than its thermic efficiency entitles it to be for engines larger than say 40 or 50 horse power.

If, however, the rates for gas were to be reduced 50 per cent., as I believe might be done when used in large quantities, for fuel purposes, the gas engine even in small sizes would give power at a cost of 1 cent per horse power hour, and thus compare very favora-

widely used when once the fact is generally appreciated in this country as it is in England that a pound of coal gives far more power when made into gas and run through a gas engine than if burned under a boiler to generate steam for a steam engine. That the cost of fuel is almost a controlling factor in the question of installing gas engines is shown by the fact that the demand for large engines suited to our natural gas regions is steadily increasing.

As regards gasoline engines, improvements in the details, and particularly in the electric igniter, have placed this motor in position to compete with high grade steam engines, yielding as it does power at a cost of $\frac{3}{4}$ to 1 cent per horse power hour. The underwriters' requirements, however, restrict the gasoline engine to localities where there is sufficient space available to place the gasoline storage tank 30 feet away from any building. But for country houses and hotels, village water works, factories, or lighting stations the gasoline station seems just what the conditions demand, and there are a number of engines in use for such service, besides others to operate dynamos to charge storage batteries. The demand for gasoline engines is growing for out of town power plants, especially in the larger sizes for electric lighting and factory service.

The lessened sales over former years of the small sizes of gas engines, say 5 horse power and under, are, perhaps, due also in great measure to the competition of the electric motor. A small gas engine cannot be sold for the same price as a small motor, because it is a much more difficult and expensive machine to build. But it is found, as a rule, that those who install such machinery consider only the first cost and do not consider at all the cost of operating, which is a matter of vital importance. For example, a 3 horse power electric motor may be bought for, approximately, one-half what a first-class 3 horse power gas engine will cost. (The motor, it may be remarked, will weigh about 450 pounds, while the gas engine weighs about 1,500 pounds.) The difference in price may be, say, \$150, while the difference in cost of operating may be, as shown by actual examples, as much as \$200 to \$240 per year, or nearly enough to pay for a gas engine the first year. In fact, careful comparison of costs of operating gas engines and motors doing the same or equivalent work has shown the motor to cost from two to three times as much to operate as a gas engine.

Were this item of cost based on actual charges for street current more generally known, instead of their being in New York city about ten times as many small motors as gas engines in service, the proportion might be reversed. Abroad the cost of operating is considered very carefully, and first cost in its due proportion, which may account, in part, for gas engines being used so much more largely than here.

As regards the application of gas engines to isolated electric lighting, a few instances may be cited. The direct connected plant of 500 lights capacity installed at the house of the American Society of Civil Engineers, 220 West Fifty-seventh Street, has been in service nearly a year and has proved satisfactory, the cost for fuel and attendance being about one-half that of street current, and the quality of light and regulation being excellent.

The two cylinder Nash engine gives two impulses on the crank shaft every two revolutions, instead of only one as in the single cylinder engine, and the governor is so sensitive that it automatically regulates the speed to within 2 per cent. from full load to no load. Besides this, a special coupling, which connects the engine and dynamo, is so adjusted that it is impossible for the speed of dynamo to vary but very slightly either way from normal speed before it is corrected by the coupling and the governor acting jointly. Regulation, in fact, is so close that the voltmeter shows less than one volt variation under changing loads.

At the civil engineer's house they installed a low pressure steam heating apparatus for warming the building, while gas engines are used only for the electric lighting. Some of our steam heating engineers were disposed to question the wisdom of this arrangement as compared with a steam lighting plant and steam for heating, but the result, in this case, has justified the choice and shown the economy of departing from standard practice, which has compelled the use of a steam plant, oftentimes, solely because it provided exhaust steam for heating, and because it was thought, no matter how wasteful the steam engine might be, it cost nothing for the steam heating.

The gasoline engine, particularly, which places country houses in an even more favorable position than those in the city with respect to electric lighting at a very moderate figure, I regard as especially promising. What we need just now is more intelligent appreciation, on the part of architects and owners, of what constitutes first class gas engine machinery and willingness to pay a fair price for it. The market is flooded with cheap gas engines, as it is with cheap steam engines; but while it is recognized that the severe requirements of electric lighting have wonderfully developed the steam engine and that nothing but the very best engines will serve, it does not seem yet generally appreciated that in like manner only a high grade gas engine will answer for electric lighting.—Elec. World.

In the recent conventions held by German iron-manufacturers, it was strenuously insisted upon that if Germany wished to compete with other countries in the markets of the world, a reduction of the present railway freight-charges would be absolutely necessary. More than one manufacturer, according to the Centralblatt der Walzwerke, compared the conditions in America with those in Germany. In the United States, it was remarked, the conditions were ideal; but it was also admitted that Americans are more energetic and bolder in their undertakings than Germans. It was further pointed out that the manufacturing industries of Germany would soon have to support the agricultural classes, which at present depend for their existence upon land gradually becoming impoverished. It was therefore asserted that, if the industrial conditions were not improved, these classes would emigrate and actually assist American manufacturers in driving out German ironmongers from the markets of the world. German manufacturers, it was stated, could not compete for any length of time with those of other countries, particularly of England, if the government did not reduce its present exorbitant railway freight-charges.

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certainly through a distance of $\frac{1}{1000}$ inch up to $\frac{1}{8}$ inch in the direction of its length. This scale can be read through a microscope fixed at right angles to the telescope as shown, and moving with the same, so that its axis makes the same angle with the prime vertical as the latter does with the horizontal plane of the instrument. A total reflection prism is used to deflect the line of vision through the microscope through 90 degrees, so as to bring the eyepiece into a convenient position for use. In making an observation the telescope is first aligned on the upper of the fixed marks on the level staff. The micrometer is then set to zero, and the division of the scale which is nearest to the cross wire of the microscope is read off through the latter. Say this was 19, then the natural tangent of the angle the line sight makes with the horizontal is $0.19 \pm$, a correction to be obtained from the micrometer head, which is by means of a vernier divided into 500 parts. This head is now rotated till the cross hair of the eyepiece exactly cuts the scale mark, and the reading of the head is then noted. Assume this to be 125. Then the natural tangent of the angle in question is 0.19125 . On making similar readings for the lower mark on the staff the numbers might be say 17 and 823, then we should have

$$\tan \theta - \tan \phi = 0.01302.$$

The reciprocal of this is 0.76805, and the corresponding distance between staff and instrument would be 768.05 feet. This, perhaps, would be rather a long sight, and the accuracy of the instrument is, of course, the greater, the nearer the staff. We are indebted to

bly with the steam engine and give a wonderful impetus to the gas engine business.

In this connection I might say that in Boston it has recently (October 29, 1898) been arranged by the Brookline Gas Light Company with the city of Boston to reduce the price of gas for fuel purposes to 75 cents per 1,000 cubic feet, and to make graded prices for gas used for power purposes in gas engines, so that they will be for engines up to 100 horse power 1.1-5 cents per horse power hour; in gas engines from 100 to 200 horse power, 1.1-10 cents per horse power hour; and in engines of 200 horse power and upward, 1 cent per horse power hour. These prices, which are understood to take effect early in the spring, when the Massachusetts Pipe Line Gas Company will have completed their immense plant at Everett and will supply by contract coal gas of 18-candle power to the Brookline Company, will at once place gas engines, according to size, on an equality with steam engines using 5 to 6 pounds of coal per horse power hour, which fairly represents the coal consumption usually met with in steam engines of moderate size working under variable load.

In England not only is illuminating gas lower in price, but there is a much more general use made of producer gas to operate gas engines, even for powers as small as 20 horse power for factory and other service. Nothing corresponding to this is done here, except that for large powers, say 100 horse power and upward, a few gas producers are being installed for power stations and like service. Such engines compete in economy with our highest grades of steam engines.

But though progress is still slow, such plants will be