apparatus that it connects with. In the center of the room containing the piles, which are about 500 in number, is a large basin fed by several cocks, in which five or six men are constantly washing and scraping the zines and vessels.

In conclusion, we shall give a single figure to show the importance of the Central. It receives and sends 60,000 telegrams every twenty-four hours! This is exclusive of the voluminous correspondence of the press, which is transmitted by special wires, rented or ceded. —*J. Illustration.*

A BASIS FROM WHICH TO CALCULATE CHARGES FOR ELECTRIC MOTOR SERVICE.*

By H. C. LUFKIN.

THE theoretical side of the electric motor question has been very ably presented to and discussed by this Association, but thus far the practical side has been somewhat neglected.

It will be my purpose in this paper, if possible, to show that there is a general average controlling the use of machinery which it will be safe for electric light and power companies to follow in making their charges for motor service, rather than adopt an arbitrary price per horse power, regardless of the character of service required of the motor.

I have arranged what might be called a power curve, representing the approximate average actual service in electric motors in connection with the several classes of work.

This curve is calculated on motors which are only of sufficient capacity in each case to carry the full load. If the motor should be larger than is necessary to drive the machinery, the percentage of actual service will of course drop below that shown in the diagram.

By adopting a basis of averages which shall be general among members of this Association, the charges for a constant horse power of current may vary with the circumstances of its first cost in each case, but the general classification of motor service may be a comparatively fixed rule. I am not prepared to say that this is the best plan to follow, but respectfully submit the following as a possible solution of the frequently asked question, How shall we charge for electric motors?

EXHAUST FANS: First on the list of power consumers is the exhaust fan, taking it in average use. There are, however, circumstances under which its use will be limited to as low as 70 or 75 per cent. of its contract hours of service; as, for instance, in a dining room it may be cut out except during meal hours, or entirely cut out on cool days. In places of this description, however, its contract use is usually limited to three or four months in the year, and other than electric power is, by circumstances of first cost and inconvenience, but a feeble competitor. The first four applications on the accompanying list, viz., exhaust fans, blowers, ceiling fans, and fan outfits, are all more or less subject to the foregoing conditions, and therefore current supplied to motors for these purposes commands the maximum price per horse power. One important feature in the installation of ceiling fans is the countershafting to the motor.

In one recent case we had a complaint from a customer that the $\frac{1}{2}$ h. p. motor sent him would not drive two ceiling fans, and that the motor must be defective, and should he return it for repairs. We immediately sent a representative to find the difficulty, which was found, as is usual in such cases, in the countershafting, or rather the want of it. The 3 in. pulley on the motor was connected to a 6 in. pulley on the line shafting. The rated speed of the motor was 2,000 revolutions, and had it been able to develop this speed, would have driven the line shaft 1,000 revolutions and the fans a relative speed. To accomplish this would probably require a motor of 3 or 4 h. p. The line shafting driving ceiling fans usually runs about 75 revolutions. To give this speed on the line shaft with a rated speed of 2,000 on the 3 in. pulley of the motor would require a countershaft with a 24 in. pulley belted to the motor. On this same countershaft should be a 5 in. pulley belted to a 15 or 16 in. pulley on the line shaft. Fully three-fourths of the trouble found in electric motors arises from improper shafting and belting. The average make of 30 in. exhaust wheel, a $\frac{1}{2}$ h. p. motor should drive at about 400 revolutions. Say then the speed of the motor is 2,000 and the pulley 3 in., it would require a 15 in. pulley on the fan to do the work; a 36 in. wheel requires 1 h. p. to develop the same speed. If the motor speed is 1,800, the pulley 4 in., it would require an 18 in. pulley on the fan to do the work. These are the most popular sizes of exhaust wheels.

The next application on the list, open tank elevator pumps, commands the highest price for current per h. p. in the motor of any elevator application. The methods of operating the open tank hydraulic elevators in question are undoubtedly familiar to you all. Instead of the usual steam pump, a power pump of some approved design is substituted and connected to the motor by suitable countershafting to give the required revolutions at the pump. The regulation of the motor in this case should be controlled by the position of water in the lower tank, as in the case of the steam pump. And in this connection let me suggest the necessity of great care both in installation and insulation. On all installations in basements and cellars, or elsewhere, where there is the slightest tendency to dampness, raise the motor off the floor on a suitable frame or stand, and build around it, on all sides of possible approach, a low platform, using glass insulators as legs or standards to support it. So arrange this that the motor or its connections cannot be reached except when standing on this insulated platform, and the liability to a shock will be reduced to the difference of potential between the terminals of the machine. To return to the subject. Let us take for an illustration an elevator using 120 gals. of water per trip, and consuming one minute in making its entire up trip, or about two per round trip. The lower tank or water supply is on a level with the pump. The upper tank is 70 ft. above the pump, and in the piping to the upper tank are five elbows. For each elbow add 2 ft. to the elevation, or an approximate total elevation of 80 (ft.) $\times$ 120 (gals.) gives us 9,600 foot gallons. This amount would be required every two minutes if the elevator was in absolutely constant operation, or 4,800

foot gallons per minute $\times$ 8 $\frac{1}{2}$ gives us 40,800 foot pounds. This we must at least double to allow for friction in pump, shafting, etc., making 81,600 foot pounds, or about 2 $\frac{1}{2}$ h. p., say 3 required in the motor.

This class of elevator is confined almost entirely to passenger use; therefore, the service required of the motor is much more constant and the margin between the h. p. hours contracted for and the h. p. hours of actual service much smaller than in any other elevator use, excepting possibly the services in connection with pressure tank elevators in the more popular office buildings. In this case we have a maximum average use of 80; and instances, such as those of the hotels, small office buildings, etc., where the service will not exceed 60 of the contract h. p. hours. In order, however, that the electric light company shall derive the greatest benefit from this inconstant service, the installation and wiring should be the best, and only the most approved and economical apparatus employed.

The next application on our list, pressure tank pumps in connection with elevators, represents a somewhat smaller percentage of horse power hours of actual service in the motor as compared with the possible horse power hours than in the case of an open tank pump. In case of the pressure tank the water reserve is usually limited, and the motor, therefore, must be equal to the continuous operation of the elevator at maximum load. Taking this fact into consideration, and the circumstances of elevator use being about the same in this case as in the case of the open tank elevator, we have a greater ratio of difference between the possible or contract horse power hours in the motor and the horse power hours of actual service, the maximum average use being about 70 per cent. to 75 per cent., and the minimum as low as 35 per cent. to 40 per cent., depending, of course, on the character of the building in which the elevator is employed or the character of service. In calculating the size of motor required on an elevator of this description, a very convenient fact to remember is that every pound of pressure per square inch is equivalent to lifting water about 2 $\frac{1}{2}$ feet, or about 230 feet per 100 pounds pressure. By reducing the required pressure to a relative lift in feet, and knowing the amount of water required by the elevator per minute, the motor calculation becomes the same as in the case of the open tank elevator, the same allowance being made for friction, etc., as in the first case. The regulation of the motor in this case should be accomplished by the conditions of pressure in the pressure tank, as is the case with a steam pump employed in this service.

The next application of importance on the list is sewing machines. In the tests I have been able to make on this class of work I have obtained some singular results. One item of importance is the fact that the single thread machines, which are the lightest running, command the most power in operating. Paradoxical as this may seem, it is easily explained. As a rule this class of machine is used on light work, such as shirts, ladies' underwear, etc., and operated at a higher speed than any other class of machine. At equal speed the volts consumed on a single thread machine as compared with a shuttle machine is about as 2 to 3. In average commercial use, however, the positions are reversed, and the ratio of volts consumed in the single thread, as compared with the shuttle machine, is about as 5 to 3. To double the speed on a sewing machine requires about 2 $\frac{1}{2}$ times the power. The difference in volts consumed on the different makes of sewing machines is so small that we may disregard it entirely, as well as the character of work done by the machine, for the heavier the work the slower the speed and more frequent and longer stops on the machine, thus keeping the average volts per operator about constant in all cases. This leaves the speed in stitches per minute at the sewing machine the factor from which we must calculate the power required in a sewing machine plant. To illustrate this, I will give you the record of two cases which are about the average. Case No. 1 is a shop in which are thirty sewing machines connected to a two horse power motor. At the time the tests were made there were but twenty operators at work, leaving ten idle machines, the entire shafting, however, being in operation. The class of goods manufactured in this shop is a cheap grade of cotton and wool pants, rather heavy goods to sew. A voltmeter across the terminals of the motor gave the following readings with a current of 9 amperes: Minimum, 90 volts; maximum, 148; average, 119; which gives us a minimum average per operator of 4.5 volts, and the maximum average of 7.4 volts, or a general average of 4.9 volts per operator. This motor was driving the shafting for 30 machines, and as the average operators employed the year round will not exceed 75 per cent. of the shop capacity, it will, I think, be entirely fair to estimate the average volts per machine rather than per operator, as the user of the motor has contracted for power sufficient to drive his entire plant. In this case, then, we have a minimum average of 3 volts per machine and a maximum of 4.9 volts, or a general average of say 4 volts per machine. A two horse motor of 82 per cent. efficiency with 9 amperes of current will require about 200 volts to develop two actual horse power. Two hundred volts, therefore, is what the electric light company contracts to deliver, while in reality they deliver only 129 volts, or 60 per cent., or a minimum average of 90 volts, or 45 per cent. of the power contracted for. These machines were making about 1,200 stitches per minute, an average of 4 volts per 100 stitches.

Case No. 2 is a shop in which are 32 machines running at about 1,200 stitches, each being supplied with an individual motor of $\frac{1}{2}$ h. p. capacity, and the class of goods manufactured being men's summer clothing, such as white duck vests, flannel coats and vests, etc., the duck from which these vests are made being about as hard work on a sewing machine as can be found. In this shop were 24 operators at work. The maximum volts in this case was 116 and the minimum 40, or general average of but 78 volts, or about 2 $\frac{1}{2}$ volts per machine with four more operators than in the first case, in which we had an average of 119 volts. This shop has been paying the electric light company \$32 per month for more than a year, which is the price the same company charge for current for a 4 h. p. motor which approximates 400 volts, which the company contracts to deliver. This gives us a minimum average use of but 10 per cent. and a maximum of 29 per cent., with a general average of 19 $\frac{1}{2}$ per cent. In other words, the company is saving in this shop the price of a $\frac{1}{2}$ h. p. motor each month, besides making a profit on the volts actually delivered. On a contract for

three years the electric light company would be money in pocket if they would present the customer with 30 small motors, charging him \$1 per month per motor for current, rather than let him buy a 2 h. p. motor to operate the same machines, with the necessary shafting, at a charge of \$18 per month for current. Taking this average in case No. 2 of 2 $\frac{1}{2}$ volts per machine, from a 50 light machine we could run not less than 900 sewing machines, or about 18 to the arc lamp. At \$1 per month per machine an income of \$900 per month would be derived from a 50 light machine without any lamp expenses, such as carbons, repairs on lamps, globes, etc. On the average, in case No. 1 of 4 volts per machine, we could operate but about 562, say 600 machines. Divided up in shops of 30 machines and a 2 h. p. motor to each shop, we would have 20 two h. p. motors. At a charge of \$18 per month each we would have an earning capacity of but \$360 per month from the same 50 light machine.

This is but one page from the thus far unwritten history of the much maligned small motor. Still the question is frequently asked: "Can we sell current for \$1 per month for a small motor driving a sewing machine and make a profit?" As a matter of fact, 50 cents per month for small motors driving sewing machines yields a better profit to the company supplying the current than \$10 per month per h. p. in large motors to drive the same machines, besides the immense advantage which the small motors possess of keeping the circuit in much better balance, the fluctuations due to the stopping and starting of large motors being at times a serious matter. One electric light company, making rather a specialty of these small machines, rents the motor and supplies the current for \$1.25 per month per sewing machine, and reports that at this price the motor service pays them a better percentage of profit than their lamps. This company has some 200 small motors on the circuits.

A more striking illustration of the advantages to the electric light company in the subdivision of power into the smallest possible units it would be hard to find. There is a difference in efficiency of from 15 to 20 per cent. in these two sizes of motors, but this difference is fully lost to the large motor in driving the shafting, and the small motor still has the advantage of being out of circuit entirely when the machine it is driving is stopped. There is scarcely a manufacturing industry which does not possess its busy and dull seasons. This means that in no industry will over 75 per cent. of the machines or machinery employed be in average operation. The entire shafting in the shops must be kept in operation the entire year often for less than 50 per cent. of the machinery. Subdivide these same shops into as many small units as possible, and the current necessary to operate the shafting for this idle machinery will be saved, besides the saving from frequent stops while the machinery is in active use.

To return again to the list, the next two applications, picture frame manufacturers and moulding manufacturers, are very similar. Their busy seasons, as a rule, are in the spring and fall, and also follow closely any activity in house building. In the case of the larger manufacturers in this line a maximum average of 75 per cent. will possibly be reached, but probably never exceeded. In the case, however, of the picture dealer, who has a small shop in which he makes picture frames and mouldings to order, the actual service of the motor will fall as low as 25 per cent. or 30 per cent. of its contract hours; one case in our experience the actual service having reached this low average. A fair general average in this class of work would be about 60 per cent.

The next application, nickel and silver platers and buffers, are good contract customers as a rule; one case in our experience showing but an average use of 20 per cent. of the contract horse power hours. This, however, is probably an exceptional case, and as near as we can estimate on this class of work the actual motor service will not exceed in any case 60 per cent. of the contract hours; a fair average being probably 45 or 50 per cent.

The next two applications, printing presses on news and job work, are probably met with more frequently than any other. On exclusively news work, the instances where the motor is in service more than three or four hours is rare. It is, however, usual in news offices to find two or more job presses. If the newspaper printed happens to be a morning paper, the hours of news work are usually between 12 midnight and 4 o'clock in the morning, the job work being done through the day. I have in mind a case of this description. In the shop is one cylinder press and three job presses connected to a two horse power motor. This motor is on an incandescent circuit of 110 volts. To develop its rated power at 110 volts would require about sixteen amperes in the motor. An ampere motor in series with the motor while running off the morning paper with only the cylinder press in operation stood at 12 amperes. For three hours this load was practically constant, when it was thrown off entirely. This gave on the night service but thirty per cent. of the contract hours. This motor required five amperes to drive the shafting, and but eight amperes, or one horse power, to drive the three job presses with the cylinder press off. Here then is but a fifty per cent. use if the presses be used constantly; there are, however, many days when they are comparatively idle. Thirty to forty per cent., therefore, is a very safe estimate of the maximum use of this motor on the day circuit, or had the motor been a one horse power, which would have been sufficient to drive the job presses, the use would be sixty to eighty per cent. of the contract hours, probably not above 60 per cent. All printing offices will probably come within this range unless the motor be larger than is necessary to do the work.

Machine shops doing principally lathe work as a matter of course use a larger percentage of their contracted power than shops doing lathe and bench work with the same hands. In no case will the service of the motor exceed 65 per cent. or 70 per cent. of its contract use; for machine shops, like sewing machine shops, will never average over 75 per cent. of the shop capacity for operators the year round. The average, especially in the case of a shop doing much bench work, will fall as low as 40 per cent.

The driving of laundry machinery, which is our next application, usually proves a profitable contract, according to reports. This fact arises from the intermittent use of the machinery. The heaviest service on the motor will probably be found during the early part

* Read before the recent New York convention of the National Electric Light Association.

of each week, with a general falling off in work during the summer months, while the patrons of the laundry are away at the seashore or in the mountains. In this application, therefore, a 75 per cent. service would probably be an exception, with probably many instances where the service would fall below 50 per cent.

The next application, model and pattern makers, are small users of power, as their occupation requires a large proportion of hand work. Fifty per cent. service in the motor will be found a fair average maximum use, with instances as low as 20 or 25 per cent.

The next application, direct power or belt elevators, is another application frequently met. The average service in the motor is also much smaller than in any other elevator application. Let us suppose a case of

the current out when the motor is not in use, the average use would drop to 20 or 25 per cent., instead of 37 per cent. In the case of a direct power passenger elevator, the use might possibly run up to 60 per cent., but this would be exceptional.

Coffee mills will average from 40 to 60 per cent. of their contract hours, manufacturing jewelers about the same, while retail jewelers will run as low as 25 per cent. Ice cream freezers will not average over 25 per cent., but as the contract season in this case is usually short, they should be rated at least a 50 per cent. basis, except, possibly, in cases where the customer pays the cost of installation and wiring, which is usual in these cases.

A dentist is one of the smallest of power users, so small, in fact, that if every one in the city were con-

[ENGINEERING.]

WAR SHIPS OF THE FUTURE.

It is certainly by no means an insoluble problem in the present day to construct a ship possessing the required qualities of high speed, invulnerability to the attack of present and future torpedoes, unsinkable by guns, and provided with great offensive power and handiness, though the enormous cost of such colossal structures is a most powerful obstacle to their creation. No nation, however wealthy, could afford to construct its fleets of units, each one of which represents an immense expenditure, even though held superior to many others of inferior power, because the invulnerability and power acquired by this expenditure cannot guarantee the colossus against the dangers of disasters at sea, fire, explosions of boilers, and other possible catastrophes, nor against other still more potent agents of destruction which the future may have in store.

Being unable to obtain the necessary complete resistance to sinking when the endeavor is made to fulfill all the other requirements, the necessity will become more and more obvious, as time goes on, of obtaining that quality by sacrificing some other conspicuous characteristic of the ship. Among all the factors which now constitute the military power of a ship, that of velocity is without doubt the most prized, and also the one which has been the chief cause of the increase of cost, as well as that which more especially precludes the adoption of a form and construction of the hull which would be better able to resist the offensive development of sub-aqueous weapons.

It is the velocity therefore which will have to be sacrificed to the advance of the new weapons. This sacrifice will be no doubt strenuously opposed, as speed is always dear to the sailor, accustomed to associate this quality as a leading feature in a good design of ship, but the supreme law of the safety of the ship will force its adoption. Between the alternative of accepting the perpetual danger of being sent to the bottom at any moment or of giving up an excess of speed, no hesitation is possible in adopting this latter solution, however painful the decision may be. This modification in the qualities of a battle ship will naturally not be by itself a solution of the problem, and it will have to be followed by others, but as the most radical, and perhaps the most contested, its consequences deserve examination.

For battle ships a sensible excess of speed over an adversary was a distinct advantage, when the guns were ranged along the broadside, because in that case the swifter ship could assume a position from which she could attack the other without being herself attacked. It was also an advantage when the attack by ramming was thought likely to be adopted; but in the present day the system of rotating platforms, which defends equally nearly all the points of the horizon, has caused this advantage to disappear. The modern systems of construction and torpedoes, having led to an abandonment of the attack by ramming, have also contributed to this result. High speed was retained as a principal defense against the attack of torpedoes, and this was in part justified, when the velocity of the torpedoes was only about half that of the ship. At present both the torpedo and the torpedo boat possess a speed considerably greater than that of the battle ship, and in consequence speed can no longer be considered as an arm of defense for these last. A superiority of speed is not of very great advantage in the phases of a combat, because the pauses arising from the necessity of maneuvering interfere with its advantage being realized. The superiority of speed, it is true, confers the power of choice in accepting or refusing an action, but the occasions are rare and exceptional when a commander would be justified in making use of the latter prerogative.

A reasonable diminution in speed produces no deleterious consequences in case of an artillery combat, when it is sacrificed to obtain immunity against torpedoes. Between a Duilio or an Italia, possessing a speed of fifteen knots, but liable to be sunk by the explosion of a torpedo, and a ship of nearly equal power and of less velocity, but invulnerable to the attack of a dozen torpedoes, the choice cannot be doubtful. For that reason sooner or later large battle ships will have to accept a sacrifice of speed in order to obtain immunity to torpedo attack.

Without doubt many will dispute these conclusions, pointing out that inferior speed leads to impotence, because the quicker ship can always withdraw from the attack of the slower, and that the latter cannot escape ramming by the former. These critics forget, however, that speed given to a structure which can be easily sent to the bottom is ephemeral, and that an effective protection against torpedo attack will in a large measure be a defense also against ramming. Experience, however, will, in the end, dispose of these and other objections, as it will demonstrate that superiority of speed, if unaccompanied with invulnerability, is no secure guarantee of being able to take flight, because the high power and accuracy at great distances of the guns of the future will easily clip the wings of the fugitive. If the quicker vessel is reduced to flight on the appearance of the slower one, that signifies that the latter will be master of the field, remaining where it chooses, and where necessary to attain its object, for it cannot be contested that a ship should always have some fixed purpose to fulfill, and not alone that of flight. The slow ship, invulnerable to torpedoes, can always force her swift, though vulnerable, rival to quit any particular spot, while the same compulsion can never be exercised upon her, whether she maneuvers furnished with nets or without, and that for reasons which are self-evident.

To sum up, the renunciation of an excess of speed in order to obtain security against torpedoes is the means most adapted for clearly defining the role of such battle-ship, and for rendering her more efficacious in the field of action for which she is destined. This difference of speed between the more powerful vessels and those of less size will be accepted in future as the lesser speed of the line-of-battle ship in presence of a frigate, and of the frigate as compared with the corvette, was accepted in former days. Every ship must have some one factor largely developed at the expense of some other less essential for her particular duties. Future fleets must have their Uhlans, their heavy cavalry, and their light artillery, but their real fighting strength will consist of large vessels of reduced

THE CENTRAL TELEGRAPH OFFICE, PARIS—THE PNEUMATIC APPARATUS.

the familiar grip connected to the ordinary hand hoist with a lifting capacity of 2,000 pounds. In this case the motor is in use only going up, and the usual brake is used in coming down. Connected to this elevator in the loft of the building we have a 5 horse power motor wired to a cut-out on the ground floor. We will call the lift 45 feet and the time consumed per trip 1 minute. We will allow 60 full trips of the elevator at full load at 2,000 pounds per trip each day. This would approximate ten car loads of merchandise handled by the elevator, which is certainly above the average. This motor, we will say, is on a ten hour day circuit; its possible horse power hours, therefore, would be 5 horse power for ten hours, or 50 horse power hours per day. Sixty trips of one minute each gives us exactly one hour's service of the full 5 horse power or 5 horse power hours. To drive the shafting only while the elevator is coming down or idle would require about 150 volts, or 1½ horse power; and if this was in constant operation the balance of the day, nine hours, its total use on shafting would be 13½ horse power hours, which, added to the 5 horse power hours, gives us a grand total of 18½ horse power hours, or 37 per cent. of the contract hours. If, however, the user of the motor avails himself of the cut-out box and cuts

connected with a circuit, the load from this cause would never be felt. We will, however, put them down at from 10 to 20 per cent.

The optician uses a motor to turn his grindstones, and its use in this case will average from 20 to 30 per cent.

The last application on the list, church organs, use only from 10 to 20 per cent. of the contract service.

These are, of course, but few of the very many applications of the electric motor, and if, as I trust, the possible subsequent discussion of this general plan may establish a basis for rating motor applications, not only will the object of this paper be obtained, but a question of considerable annoyance now existing between the motor man and the electric light and power company will be solved.

In conclusion, Mr. Chairman, I beg to suggest that the supply and rates of charge for electric power have become of sufficient importance to this Association to be represented by a permanent committee, whose duty it should be to obtain from the different members of the Association, as far as possible, their experience in the supply of power, in such manner and form as shall be deemed by the committee best suited to the wants of this Association.

THE CENTRAL TELEGRAPH OFFICE, PARIS—THE GREAT BATTERY OF 10,000 ELEMENTS.