

very accurate measurement of pressure, and errors of $\frac{1}{10}$ of 1 per cent. are of importance. Recent studies of the errors of aneroid mechanisms have indicated directions in which still further improvement is possible.

The hair hygrometer is about the only type of hygrometer that seems practically available in the construction of a kite meteorograph, but it is, nevertheless, not as sensitive and reliable as we desire. Ten minutes or more are required for the hairs to show a change of 10 per cent. in the humidity. Aside from this sluggishness, the indications of the instrument are not wholly reliable and should be frequently checked and verified by comparison with readings of the wet and dry-bulb thermometers.

The greatest need in kites for future work is a more perfect means of automatic adjustment to extremes of wind velocity and considerable reduction in weight of the structure so that better ascensions can be made in light winds. The remarks already made in respect to the errors of the recording instruments indicate the nature of improvements required therein.

Stated Meeting, Tuesday, January 24, 1899.

THE PRACTICAL APPLICATION OF ELECTRIC MOTORS TO PRINTING PRESS MACHINERY.

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The past five years have seen marked advancement in the transmission of power by electricity.

Aside from long-distance transmission and railroad work, no branch of the art can show such substantial results as have been accomplished in the field of individual motor application. In this latter the application of the electric motor to printing press machinery has produced results in power saved, improved product and increased output sufficient to cause every large printer to-day to look upon electrically-driven printing presses as a necessity and not a luxury.

Passing by the early arguments used for adopting the individual motor, the engineering problems of what is the best and how shall it be applied are now ready for consideration.

It will be necessary to subdivide the subject, considering each separately, afterwards drawing conclusions from facts submitted.

The following is the definition of "geared" and "direct" motors:

Geared are single reduction motors.

Direct have the armature of motor keyed to the main driving shaft of press.

MAIN TOPICS.

Types of motors, attachment, control, protection, maintenance, cost of operation, advantages, a few facts of the power consumption of the government printing office.

These headings are themselves subdivided.

Types of Motors.—There are three kinds of motors used in printing press work, viz.: series, shunt and compound wound.

Series Motor, owing to its speed varying directly as work done, gives an unsteady and jerky motion to press, which interferes with securing the highest grade of press-work.

Shunt Motor, while giving much better results as to constant speed at all parts of the stroke of the bed of a press, is lacking in starting torque so essential in handling a press during "make-ready," as well as starting the press from all positions of the bed.

Then if lead of brushes is altered to overcome sparking, there is a corresponding change in speed of press shaft.

This fact the pressman sooner or later will discover and more than likely take advantage of on hurried work, excessive sparking from a distorted field causing him but little worry.

Compound Motor gives by far the best results for printing press work, having a stiff starting torque, constant speed and minimum sparking at moment of reversal, a constant factor in this class of work.

The commercial demands* are for a tough motor, one built to withstand rough handling, overloads, long strains of work, not similar to pumps or blowers, which is constant, but the continuous starting and stopping, reversing, producing conditions which can only be met by a motor mechanically and electrically rigid in all its details; one free from repairs, always ready to be pushed to its maximum.

Sizes.—Motors should always be sufficiently large to handle the presses to which they are attached without straining, and wound for highest efficiency at 70 per cent. of rated output.

For example, suppose we have a 5 horse-power motor attached to Huber press, bed 42 x 52 inches, running at 1,300 impressions per hour, printing 32 pages solid matter, using book ink and running under favorable conditions, the current consumption fluctuating from 12 to 30 ampères at 115 volts; allowing 8 ampères per horse-power, we have, for a 5 horse-power motor, 40 ampères, 70 per cent. of which is 28 ampères.

This press will take to start, varying according to position of bed, from 35 to 50 ampères at 115 volts.

From these figures it is seen that the press is handled promptly and properly, with ample margins, without using too large a motor.

These figures apply to presses that have been in operation some months, not to those newly installed, for often these will demand double the figures mentioned until they become "limbered up," during which time the motor will have a little extra work to perform, but a good motor will withstand this ordeal without harm.

In selecting the size of a motor, do not figure too close; get one sufficiently large to do your work without loss of time to the operator.

The price of motors is not direct as the horse-power, a 5 horse-power costing only about 15 per cent. more than a 3 horse-power motor, while you obtain 66 $\frac{2}{3}$ per cent. more power.

The efficiency of a 3 horse-power and 5 horse-power

motor, both running under load of 2 horse-power, will be within 2 or 3 per cent. of each other, thus placing each on substantially the same basis as to commercial efficiency.

This reserve power will prove a valuable source of revenue before the year is closed.

Belted, Geared and Direct-Connected Motors.—The main advantages to be gained from the individual application of electric motors to printing press machinery are steadiness of power as applied to main driving shaft, absence of overhead belting, economy of floor space, increased output and ability to place presses in a room irrespective of a main line of shafting.

The main difficulty with belted motors is the slippage of the belts, which frequently causes poor register and slurring; with overhead belting this is further increased from dust, dirt and scales, which are constantly given off from the surface of the belts, battering plates, and the obstruction to light in the room all tend to decrease the output.

In fact, the belted individual motor has only two advantages over the main line driving, viz.: Location and independence of main line, in case anything happens to belting which might necessitate shut-down of all the presses.

As it retains all the disadvantages of the main line drive, it should be discarded where good work is wanted.

The geared and direct-connected motors only will hereafter be considered.

To reach a conclusion as to which is the better will, in most cases, necessitate an individual consideration, first, by the electrical engineer and the press builder, and, finally, by the proprietor, who pays the bills.

The principal features of each should be considered separately.

Geared Motor.—This must be of moderate speed, not of a high speed, for then the reductions, motor to press, are prohibitive.

Speeds should be from 1,000 revolutions per minute for 1 horse-power, to 500 or lower for 15 horse-power; this will permit of a suitable mechanical reduction and attachment to presses whose main driving shafts vary in speed from 90

to 175 revolutions per minute. When this is exceeded, it is almost impossible to make the press—one of the large types—run quietly, and if noise is an objection, the direct-connected type becomes advisable.

Hardly any two makes of presses have the same shaft speed, nor are the diameters of shafts the same; so for presses of same sized bed and production there is required for each make of press different ratios of reductions, which can be easily supplied by gearing, always using the standard motors.

While with the direct-connected motor, the armature, being keyed to press shaft, must be built especially for this individual type and make of press.

Its interchangeability with other presses of different manufacture is a great rarity.

If press is sold or replaced by another, the motor must be made over to suit, or else thrown away, while the standard geared motor is always ready for use with a change of gearing.

The ratios in presses vary from 4 to 1 to as high as 12 to 1.

Press ratio means for every 4 or 12 revolutions (as case may be) of press shaft there is made one impression.

In some cases the geared motor takes up more floorspace than a direct-connected, but not always, notably in the stop-cylinder type, which has driving shaft at the rear of press, enabling motor to be placed under the delivery table, reducing the floor space even of belted presses.

Should trouble occur to the "direct" it is much more serious, for this means a shut-down of the press, until injured parts can be repaired or furnished by factory.

Waiting for special made motors to be repaired or rebuilt is very tiresome, as those of us know who have to place ourselves at the mercy of manufacturers.

Duplicate geared motor armatures can be kept on hand and change made easily during "make-ready," with no loss whatever of production.

Owing to the wide variation in speeds, bore of shafts, it is impracticable to keep on hand "direct" armatures; cost

is prohibitive to keep a special armature for each size press.

Increased cost of direct over geared is from 25 to $33\frac{1}{3}$ per cent. for new presses as they come from the factory ; cost of installation about the same.

Difference in cost of electrically equipping presses already supplied with belting depends largely upon circumstances, whether shaft has to be lengthened, turned off, etc.; but cost is nearly equal if gearing has to be bought and pulleys cannot be sold.

These figures refer to motors of about 5 horse-power and speed 175 revolutions per minute and up; smaller sizes, as well as lower speeds, make material advantages in favor of geared motors.

Voltage should be either 115 or 230. Five hundred volts is too high to have about so much metal which employees are constantly touching.

Attachment.—I wish to call particular attention to this part of the subject under consideration, for it is one that the electrical engineer is more likely to slight, it being wholly mechanical engineering.

First, in every case make the motor part of the press; it must *not* be placed on a separate foundation; it is absolutely essential that this be rigidly adhered to in all cases where satisfactory results are expected, for otherwise the gearing will get out of line. In the case of "direct" motors, there is liability of the armature hitting against the pole pieces or else bind the main press shaft sufficiently to get a hot box and cut the shaft.

Next in importance is to provide a proper foundation; in most cases up to 3 horse-power, an iron bracket of sufficient strength, securely bolted to frame of press, will meet all the requirements; in all sizes from 5 horse-power and upwards, an extension of masonry foundation on which press rests should be made; cast-iron motor base must not only be bolted to press, but anchored to the masonry foundation by grouting in cement or with anchor bolts—in many cases both should be done, thereby obtaining a foundation amply massive to take care of all the jars and strains to which

the motor will be subjected, without running the risk of loosening the bolts in foundation and getting motor out of line.

In a "Huber" press, running at a speed of 1,500 impressions per hour, the bed is travelling at the rate of 300 feet per minute; weight of bed, with form, over 1,000 pounds; a total of over 300,000 foot-pounds to take care of, while the press is running at full speed within a bed travel of 4 to 5 feet, with reversal following immediately. To cause a more sudden stoppage would be disastrous to the machinery of the press.

The rough usage to which the electric motor is subjected on presswork is such that if repair bills are to be kept down, the initial cost must not be the sole guide.

In the case of direct motors, the outboard rigging makes it much easier, at the same time presenting a more graceful appearance when finished, to attach motor to press without either foundation or motor sub-base. In this case the supporting brackets must be rigid and bolted to press with a "driving fit," for, when play is left in bolt holes, trouble is sure to arise sooner or later from the motor shifting its position.

Even with direct-connected motors, it is best, wherever possible, to provide a sub-base, for reasons mentioned in connection with geared motors, as well as the assistance received during installation. The proper handling of motors weighing from 500 to 1,100 pounds, while working to a "driving fit," with the ordinary appliances at hand in a printing office, is not rapid or satisfactory work.

Gearing should consist of rawhide pinions with cast-iron gear wheels, being sure to have both pinions and gear wheels cut by the same factory. Having rawhide manufacturers cut the pinions, and press builders or some other machine shop cut the gear wheels, invariably results in noisy running gears. Engineer should give personal attention to this when installing work.

The gear wheels should be fitted with taper bore, key-way and cap on end of shaft. The use of set screws is not satisfactory.

The pinion should be of the best grade rawhide, having brass sides and sleeve, latter thicker than depth of keyway. Face wide enough to allow for armature vibration, without metal sides running on face of gear wheel.

Teeth should not be too fine pitch. My experience has been that, for ordinary work, a 4-pitch diameter tooth is thoroughly satisfactory, showing little wear after continuous use for several years.

On heavy presses it is advantageous to connect, by means of a stiff wrought-iron bar, the press and motor bearings.

Satisfactory ratios of reduction, motor to press, from 10 to 1, desired speed not exceeding 120 revolutions per minute; 5 or 3 to 1 on higher speeds. These will run well, and with little noise or wear, for several years.

Great care must be exercised in selecting the workmen that are intrusted with the lining of the gears; this is one of the most important parts of the installation of the electrical equipment, and should be intrusted only to trained experts in this class of work.

Position of Controller.—In attaching the controller to the press, care and judgment should be exercised to place same so that the handle is convenient to the press feeder, the direction being away from the body while starting press and towards the body to stop, which at times must be done immediately to prevent sheets getting on the roller, etc.

This should be fastened to a cast-iron bracket, when possible; otherwise, wrought-iron supports well braced will answer.

Wiring demands high-grade insulated wire, so protected that it cannot meet with mechanical injury.

The hanging of wires from the ceiling should not be permitted, as it is not safe, at same time interfering with the proper handling of the press.

On most presses the feeder is on the opposite side of the press from the motor, therefore, wires must be run across press to same. About a press is much oil and ink, all detrimental to the insulation of the wire, which must be kept perfect to insure uninterrupted use of the press. This can be secured by using highest grade rubber wire, taped and

braided, enclosed in a continuous length of flexible tubing, these finally encased in black iron pipe, said pipe to be firmly bolted to press, if running across, or cemented into foundation with painted joints if running underneath press. If this method is adhered to, the thought of ever having trouble from your wiring may be placed to one side.

Personal experience has shown that, where this method has been followed, we have never had a leak on our wires.

The knowledge that wiring when once installed is perfect and will give no trouble is fully appreciated by the engineer in charge, and will be by the proprietor, after a few *expert* bills for testing wires have been paid.

Keep controllers and rheostats as far away from the floor as possible; they will be kept cleaner and are less liable to damage from scrubwomen and trucks than if placed on the ground.

Control is a subject to which more care and thought has been devoted by electrical engineers than all the rest of the equipment combined.

A casual glance at what is necessary to properly handle a printing press before starting to print will disclose the problems which had to be solved. Take a large flat-bed two-revolution press, bed 42 x 52 inches, or one large enough to print 32 pages 16mo at an impression, as an example. Starting from the "make-ready," when the pressman places the form on the press and begins to see what is necessary to produce good work. In placing "overlays" on the cylinder, the press is moved a few inches forward, then reversed, or the cylinder is turned ahead a half revolution, then reversed a quarter, etc. In placing plates on the press, many times the bed is needed to be moved not over an inch or so; all this must be done quickly and absolutely, for unless the press is under perfect control an accident may easily occur. The more perfect the control, the less time is the press idle and becomes a wage-earner instead of an interest-eater.

After the press has been started and working satisfactorily, absolute control must continue, as there will be occasion to stop same quickly within stroke of bed or even less;

this must be while under full speed and in such a manner as not to jar or injure the press.

Speed Control.—There are several methods in vogue at the present time, viz.: Resistance in series with armature, commutated field, field control by insertion of resistance, combination of resistance in armature and resistance in series with field, having the former take care of about two-thirds range of speed, then depend on weakening the field for the balance.

The latter method gives the widest range of speeds and for direct motors is the most satisfactory to install, both to seller and purchaser.

Most every engineer, without exception, cries down the armature-resistance method as grossly extravagant. On the surface, or from a theoretical standpoint of the motor itself, this is correct, but what are the facts in actual practice?

In most large offices certain presses are used on work which requires nearly always the same rate of speed, although the character of the work may not be uniform. These presses can be fitted with gearing suitable to give proper speed when motor is "full on," using the resistance only as a starting medium, rather than a speed regulator.

To convince myself what the actual difference was in commercial work, I conducted experiments and tests, lasting over six months, taking geared motors with armature control, and "direct" having commutated field.

Method of test was as follows: To each press was attached a "Thomson Recording Wattmeter," carefully calibrated. Readings were taken daily. The output was taken from the daily report of pressman to foreman of the press-room.

These were all attached to same size and make of press, doing regular bookwork. From day to day there were some striking differences, yet at the end of each month and the close of the six months' test the armature control held its own, showing an efficiency not usually accorded to it.

The following is the test in detail:

OUTPUT AND POWER CONSUMPTION, HUBER PRINTING PRESSES (BED, 42 x 52).
JULY TO DECEMBER, 1897. GOVERNMENT PRINTING OFFICE.

No. of Press.	Watt Hours Consumed.	Work Done, Impressions.	Watt Hours per Impression.	Type of Motor.	Method of Control.
4	1,055,400	788,843	1'337	Direct.	Commutated field, compound.
5	832,700	572,991	1'453	"	Resistance in field, shunt.
6	1,152,800	766,512	1'503	"	Commutated field, compound.
7	861,200	436,552	1'972	"	"
8	998,800	525,010	1'902	"	"
9	777,600	487,306	1'595	"	"
10	1,265,700	729,986	1'733	"	"
11	1,274,000	754,884	1'687	"	"
12	931,300	563,731	1'652	"	Commutated field, series.
13	1,250,100	606,247	2'062	"	"
32	819,400	593,854	*1'379	Geared.	Resistance in armature, compound.
33	975,200	474,170	†2'056	"	"
34	1,025,600	650,046	1'577	Direct.	Resistance in field, shunt.
54	1,273,000	739,903	1'720	Geared.	Resistance in armature, compound.
65	1,411,200	809,219	1'743	"	"
67	899,984	579,646	1'552	"	"
69	1,115,200	707,100	1'577	"	"

* Maximum speed of press, 18 impressions per minute.

† " " " " 25 " "

This clearly shows that the geared motor with armature control is not a back number. No law or rule can be given as to which is the most economical method, owing to the wide range of conditions entering into the solution of each problem; this should be intrusted to a competent engineer to decide.

Adherence to simplicity, avoiding all complicated methods of control consistent with economy of current consumption, produces the most satisfactory commercial conditions.

Controller should be of the barrel type, compact, having all contacts inclosed and protected. This should be provided with only *one* handle, and having five or six speed contacts with two points reverse. The necessity for limitation to one handle is that two will produce confusion

when quick action is required ; if operator is told to do this and then that, he generally does that, then this. With one handle a demand for instant reversal is quickly responded to, as there is but one thing for the operator to do—*i. e.*, push the handle in the opposite direction from existing conditions. This very soon becomes instinct with the press-feeder and mistakes are unknown.

The controller should be so made that it can be easily repaired and inspected, provided with ample carrying capacity and liberal surface contacts, allowing not more than 40 ampères to square inch ; cylinder should be convexed and fingers concaved ; where large quantities of current are to be carried by fingers, the latter should have copper braid connecting tip with base ; larger size controller should be provided with special contacts for breaking current, not depending upon them to carry current while in constant service—this will reduce heating to a minimum ; it must be easily handled and free from breakdowns.

When a first-class controller has been produced, the manufacturer has won half the battle, for herein has been one of the greatest sources of trouble the printer has had with individual motors, viz.: getting suitable control coupled with a substantial and reliable controller.

Reduce all automatic devices to a minimum, if not dispensing with them altogether on the controller ; they are unnecessary, and as such are sources of trouble. A quick brake reduces sparking, thus lessening the chances of undue heating of contact fingers while in use—its adoption is an advantage.

Push buttons about a press, which is hand-feed, are superfluous and should only be used in connection with automatic feeders.

The great range of speed stipulated by some is seldom used in actual practice ; ranges of running speeds from ten to thirty-five impressions per minute, as I see discussed, are so rare in large commercial houses as not to be worthy serious consideration. Cut work is not done at the high rate of speed of common job presses, nor are the same presses used for both classes of work and expected to pro-

duce the best results. Running the press at high rate of speed would soon make it unfit to do first-class half-tone work upon. And running common job printing on slow-speed cut presses would not pay. What is necessary in determining the range of speed of a press is the knowledge of the class of work to be done most thereon and how it is to be fed. A general knowledge of presswork and common sense will, as a rule, settle these problems satisfactorily.

If extreme limits are insisted upon, the proprietor must suffer and take what he can get as to economy and first-class work.

Protection includes a larger field than the electric motor—the printing press and operator should be fully considered.

Experience has developed the fact that satisfactory protection is secured only by means of an automatic circuit breaker; this applies not alone to the motor, but the printing press and its operator as well.

In the individual application of the electric motor, in most cases, the price of the motor is small, compared to the machine to which it is attached. For instance, the cost of an ordinary two-revolution front or back delivery flat-bed press, book size, is about ten times that of a first-class electric equipment for same, installed complete in every respect.

The motor will stand more rough handling than either the printing press or the operator, and still be in condition to do its work properly, conclusively showing that more than the protection of the motor is demanded. The results of the exclusive use of circuit breaker for printing press work are the reduction of repairs on presses 50 per cent., stoppages practically eliminated, with prolonged life of machinery. Presses can be handled promptly from any position, with circuit breaker set at 50 per cent. above capacity of the motor, providing the press is in free running condition; if it is not, the circuit breaker is the best tell-tale extant. The failure of the pressman to properly clean and oil his press is followed by a frequent opening of the circuit breaker, showing something is wrong and needs attention.

A personal experience in this line may help to explain more clearly the point in question.

Shortly after equipping some of the first presses in the office, constant complaints were received from one especial press, that the motor was not working satisfactorily, power unsteady, press would not start unless assisted by a laborer, circuit breaker was a nuisance, as it opened constantly. This continued until the press refused to work at all—motor was unable to turn it over. Investigation showed the main press shaft to be fast in its bearing, the pressman having failed utterly to oil or care for the press.

Henceforth we were not in receipt of complaints from that press; the ability of the circuit breaker to show up so clearly carelessness on the part of the workman established for itself a reputation which is still of the highest.

Injuries from rough handling and sudden starting are very materially eradicated. The impact from a blow four or five times the capacity of a motor, which a fuse permits, must expend itself somewhere; if it does not break a part, it strains the entire press, and constant repetition means lost motion in running gear—this is fatal to good printing.

This was such a serious objection to the individual connecting of electric motors to printing presses, that one of the oldest and most prominent press builders in this country came out flat-footed against this method, and said we must have a belt as a driving gear, for this would slip or run off the pulley; gearing meant the wreck of the press if anything went wrong. They were right when fuses were the only method of protecting the press, as they were not quick enough to prevent trouble. But with the use of a reliable circuit breaker all these objections are swept away, and we have better protection a hundredfold than slipping belts.

One word about the protection of the employés before leaving this subject. Carelessness bred by familiarity is the great source of danger to the majority of employés, and lessening of results from this demands thoughtful consideration. By way of illustration I will narrate two such instances, which have come under my personal observation.

(1) A laborer was cleaning a press, while in motion, with cotton waste; this caught in the gear wheels, drawing in his hand. The circuit breaker opened promptly, owing to the increased power necessary to overcome the resistance of his fingers between the gears. The press stopped before the entire hand was drawn into the moving machinery—three fingers only being hurt, one sufficiently to need amputation. Had fuses been the protection instead of a circuit breaker, nothing could have saved this man's entire right hand.

(2) A young lady passed too close to some moving machinery—a place where all passage was prohibited, on account of the closeness of rapid-moving presses—her dress skirts in some manner became entangled in the moving gear wheels, drawing her over against the machine; the quick opening of the circuit breaker stopped the press, with a result to her of a torn dress and a nervous shock.

The results which would have occurred in both instances, had circuit breaker not been in use, are sufficient to justify the employes in expecting that the highest type of protective devices will be used wherever possible.

The flexibility of the circuit breaker, in that it protects more than the motor, saving during the year in repairs more than its cost, clearly shows that it is a wise investment.

When installing an individually equipped printing press, the printer should insist on its use.

Maintenance.—Under this heading offices of reasonable size only will be considered, also assuming that presses are in constant use. Here the most satisfactory course to pursue is to have the care, inspection and responsibility of maintenance located at one source. One man should be intrusted with this work; a little study in systematization will accomplish all this while presses are "making ready," or at least so as not to interfere with work of production.

Inspection once in two weeks or once a month will do, in offices not too busy; this will keep down repairs, and, most important of all, keep the plant in *AI* running condition, ready for anything.

Leaving care of motors to pressmen and laborers is a bad practice for everyone but the repair man. Not alone will the repairs increase, but, most serious of all, the press stops earning money when out of order, and at \$10 or \$15 a day this becomes expensive.

A good man who is able to turn off commutators, keep controllers in order and has a general idea of the electrical and press equipment, will pay for himself many fold during the year.

Small offices, like our branch offices, we look at once in two months.

Cost depends on what you are able to secure the services of such a man for—\$2.50 to \$3 per day.

Records should be kept of all repairs made and material used, if exact cost of maintenance is desired. This provides means of tracing where delays occur, whether in press proper or its driving motor.

Cost of Operation.—Herein figures can be used to obtain nearly any result desired, unless we demand full particulars, necessitating elaborate statement of all existing conditions. Having made most careful tests, the manufacturer cannot be guaranteed that his plant will operate within test figures, unless all conditions in commercial work are similar; these are impossible, so we are forced to make a test covering months of work, striking a balance from the results obtained; these will give average commercial figures, which in most cases will show an increase over a short test under favorable conditions.

To realize how much depends on the pressman, I desire to call attention to some facts with regard to two new presses recently installed in our office. These were "Century" two-revolution front delivery, bed 43 x 56 inches; connected to each press was a C-W, 2-100 compound motor, speed 130 to 230 revolutions per minute.

All went well for a month or so, then complaint was made that one of the presses ran slower the longer it was in operation. An examination disclosed the fact that the motor was apparently not large enough for the press, as the fields and frame became so warm that the hand could

not be held on it for any length of time. Speed dropped from 180 to 140 revolutions per minute, after which circuit breaker was constantly opening, and it became necessary to shut down press every two hours or so that motor might cool off. A test showed that the press took 46 am-pères at 120 volts; speed, 144 revolutions per minute; this was on fifth speed; moving handle to sixth and last point with circuit breaker set at 58, latter would open every time; this was reset at 70, and ammeter indicated 60 when change was made to last speed; current used, 48 am-pères at 160 revolutions per minute. Press labored and did not run smoothly.

On examination, we found that the track gibbs had been set up too close; after properly adjusting these and having press thoroughly oiled, we increased speed to 180 revolutions per minute, current consumed dropped to 30 am-pères; even then the press was stiff, for its companion was running at 182 revolutions per minute on 22 am-pères, both doing same class of work.

This showed the press was taking 60 per cent. more current than it should had only ordinary care been used, while it was consuming 100 per cent. more than its duplicate, working under similar conditions.

A commercial figure ought to show an increase of 15 to 20 per cent. over efficiency test.

A hurried glance at the comparative cost of operating belted, geared and direct-connected motors is desirable, although a complete analysis is impossible to include in this paper owing to its length.

Belted motors, unless grouped, will not be considered, as they have no commercial standing for economy.

First, considering grouped presses of medium size, running from main line shaft, driven by a single motor. A line of drum cylinder presses of various makes, operated by belting afterwards driven by individual motors, gives actual commercial condition worthy of comparison. Taking, for example, thirteen drum cylinder presses in a row, with belting reduced to a minimum, a large motor belted to center of shaft, thus distributing load equally on hangers;

using a 15 horse-power motor, so with all presses at work motor is running at about 75 per cent. load—very favorable conditions.

During two months these presses made 2,892,175 impressions, consuming 1,601,200 watt hours, or an average of .553 watt hour per impression.

As soon as possible after equipping these presses with 2 horse-power geared motors wattmeter records were taken. For four of the heaviest running presses, a six months' continuous test showed the following :

Impressions, 3,813,542. Watt hours, 1,851,100, an average of .485 watt hour per impression, a saving of 14 per cent.

While disconnecting presses one by one, to equip same individually, the average consumption per impression for the remaining presses increased very rapidly. With five presses working we used between 50 and 60 per cent. more current per impression.

Geared vs. Direct shows that up to 5 horse-power the geared is more economical. In 5 to 15 horse-power, there is not much difference. Economy of operation should not be the guiding spirit in the selection of motors of these sizes. From 25 horse-power up, the direct motor has many advantages, especially for newspaper work.

Cost of Presswork.—A web press, printing at the rate of 6,000 impressions per hour—this includes cutting, folding and printing four signatures of 16mo or 64 pages, including all stoppages—will produce in a day 2,304,000 pages, an average of 384,000 pages for each hour. The average current, including "make-ready," etc., is .7 watt hour per impression; 91,428 pages per hour per kilowatt; at 5 cents per kilowatt hour, there will be printed, cut and folded 18,285 pages for 1 cent.

A good day's work for a flat-bed press, bed 42 x 52 inches, running at 20 impressions per minute, is 8,400 impressions in eight hours, of 32 pages each, with a total of 256,000 pages for the day.

Average current consumption is 1.5 watt hours per impression, or 21,333 pages per kilowatt hour; at 5 cents per kilowatt hour is produced 4,266 pages, as against 18,285 by

the web presses for the same money (1 cent), making an output for the webs four and one-half times that of the flat-bed presses, with same current consumption. The quality of the work of the former is not always as good as the latter, yet is more than compensated for by the folding and cutting.

A card-press, which prints both sides, making slitting and cross-cut from a web of cardboard, is not a usual press. The following is the output and power consumption for five months :

Impressions	8,362,750
Kilowatt hours	580.6
“ “ per impression0694

Four cards being printed at each impression, there was a total of 33,451,000 cards. With current at 5 cents per kilowatt hour, 11,500 cards were printed for 1 cent.

Main Pressroom, Government Printing Office.—In this room are forty-nine presses, including three large web presses ; of the balance one-half are large-size book presses, the remainder of double-medium size, attached to which is an aggregate of 190 horse-power in motors.

During the month of November, 1898, the presses made 5,403,032 impressions, consuming 6,542.8 kilowatt hours, an average of 1.21 watt hours per impression.

6,542.8 kilowatt hours at 5 cents, \$327.14 : or 165 impressions, allowing 12 pages for each impression, we have 2,000 pages for 1 cent.

Power Plant, Government Printing Office.—The entire power, exclusive of heating, lighting, fans, etc., consumed during the month of December, 1898, from 8 A.M. to 4 P.M., during 27 working days, 22,516 kilowatt hours, 834 kilowatt hours per day, or 104 kilowatts per hour. Connected to the power circuits are 700 electric horse-power, including electric elevators: 575 electric horse-power, without electric elevators. Daily consumption is about 100 kilowatt hours for elevators, thus giving the following ratios:

5.1 horse-power connected to power used.

6.2 horse-power connected (exclusive of elevators) used.

Largest swinging power load we have ever had is 180 kilowatts, or a ratio of 2.9.

Current consumption during November, 1898, for foundry, 3,025.2 kilowatt hours, average 12.2 per hour; folding room, 1,295.8 kilowatt hours, average 5.4 per hour; bindery, 1,875.2 kilowatt hours, average 9.7 per hour.

Advantage to be gained from changing over from belting to individual electric motor for printing-press work is not alone in power saved, but better grade of work, less spoiled sheets, cleaner, healthier rooms for employes, less repairs to machinery, and, most of all, an increased product without a corresponding decrease in value of presses by running at too high speed.

Output of the government printing office pressroom has been increased 15 per cent. A few calculations will show what this means in an establishment operating continuously 100 presses, each earning, at the smallest figure, \$10 per day, or \$300,000 for the year. 15 per cent. of this is \$45,000, a sum that makes the saving in motive power dwindle into insignificance. A few years will pay for the entire electric equipment, including the lighting.

If there is any printing office in the country where a reliable power must be had, it is the government printing office. We run 24 hours daily during Congress, and keep lights going throughout the year, never shutting down our power plant. We issue a daily paper, the *Congressional Record*, having to catch mails same as any other daily. Then all bills introduced, together with the proceedings of Congress the day before, have to be on each member's desk by 10 A.M. To this must be added the printing furnished the various branches of the government, consuming a daily average of 25 to 30 tons of paper.

Our recent war with Spain has made demands in excess of anything heretofore.

At the end of the recent popular bond issue, the Treasury Department wanted 2,000,000 copies of circulars Monday, copy for which was received late Saturday. They had wagon-loads waiting at their doors Monday morning. This is but one instance of many we have been called upon to execute.

There has never been a hitch in the motive power; not a motor has given out. In fact, such a freedom from interruption of power has never been known in the history of the office as during the past three years, or since we have adopted electric power.

The most brilliant achievement during the year was the printing of the "Maine Report." "This consisted of 298 pages of text, twenty-four full-page engravings and one lithograph in colors, and although the originals of the illustrations were not in the possession of this office until 3 o'clock P.M. of March 28th, and the manuscript of the text was not received until 6 o'clock P.M. of the same day, complete printed copies, in paper covers, were placed upon the desks of Senators and Representatives by 10 o'clock of the following morning."

In the treatment of this subject, necessarily many times subdivided, I have tried to mention, in a brief way, all essential points, a detailed consideration of which would exceed the limits of this paper, yet hope in the future, at your discretion, that these may be clearly explained by illustrations and carefully prepared tables of data now in course of compilation.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, April 19, 1899.

IMPROVED METHODS FOR THE PURIFICATION OF SEWAGE AND WATER, AS SHOWN IN THE OPER- ATION OF THE MUNICIPAL PLANT AT READ- ING, PA.

BY JOHN JEROME DEERY,
Architect and Engineer, Philadelphia, Pa.

(Concluded from p. 239.)

During the winter seasons the plant has been in continuous operation, notwithstanding very hard freezing weather. The temperature has frequently been below zero. Last winter, during the blizzard, the temperature was below zero