IMAGE EVALUATION
TEST TARGET (MT-3)

1.0 2.8 2.5
3.2 2.2
3.6
4.0 2.0
1.1
1.8
1.25 1.4 1.6

6"

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [ ] Coloured covers/ Couverture de couleur
- [ ] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [ ] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [ ] Bound with other material/ Relié avec d'autres documents
- [ ] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments:/ Commentaires supplémentaires:

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [x] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [ ] Includes supplementary material/ Comprend du matériel supplémentaire
- [ ] Only edition available/ Seule édition disponible
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X				14X				18X				22X				26X				30X		
											✓											
		12X				16X				20X				24X				28X				32X

The
to th

The
poss
of th
film

Orig
begi
the
sion
othe
first
sion
or ill

The
shal
TINU
whic

Map
diffe
entir
begi
right
requ
meth

Please read and send in as full a discussion as possible at earliest date.

The Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—*(Subject to revision.)*

N.B.—This Society, as a body, does not hold itself responsible for the statements and opinions advanced in any of its publications.

MODERN WORK-SHOP DESIGN.

By A. PRINGLE, M. Can. Soc. C.E.

It should be explained at the outset that the writer shall only attempt to cover the subject in a general way and shall not offer any lantern slides of modern work-shop structures, or details of construction, for although they might be interesting in a manner, yet no really new features could be presented, and the best that can be said of most modern work-shop structures in Canada to-day, is that certain recognized principles have been followed in their construction in possibly a somewhat modified form to suit the existing conditions.

Generally speaking, it may be said that the advantages of modern work-shop design have not been appreciated until recently. The mill or factory engineer, outside of a few special industries, has been, comparatively speaking, unknown. It was held by many manufacturers, or their managers, that they knew just what they required in the way of plant and machinery; and having determined that an extension of works was necessary, additional land was secured as near the existing plant as possible, the millwright and local builder were called in and directed to erect a building to dimensions that would best suit the property—one, two, three, possibly four stories in height. The building completed and the machinery delivered, planning would commence as to how the machinery could be located to best advantage. Of course, the superintendent had undoubtedly planned the whole arrangement in his mind at the commencement, but when it came to placing the machines it would be found that he had quite neglected the detail that there would be columns and beams supporting the upper floors, all of which naturally interfered with his mental layout, and possibly in the end, the whole arrangement of plant would have to be changed entirely from what he originally contemplated, and in all probability some important machine would have to be placed at some distance from its proper location, in possibly a dark corner of the shop, necessitating the almost continual use of artificial light, also requiring a special line of shafting to operate it. But most serious of all would be the daily expense of handling materials to and from this machine, possibly throughout the length of the shop.

BUILDING.

The building also would, in all probability, be defective in many respects, not necessarily that the materials or workmanship were faulty, but rather that they were not arranged or proportioned to give the best results in the service required of them. For instance, foundation walls, although properly constructed of good materials, would be laid upon a poor bottom with inadequate footing courses for bearing. Thus, frequently, was an expensive building jeopardized in avoiding a few hundred dollars for piling or extra walling to obtain a solid foundation.

In the construction of the upper floors it would frequently be found that the joists and flooring were capable of sustaining with safety fifty to one hundred per cent. greater floor load than the beams upon which the joists rested.

During the present year the writer had occasion to examine plans and specifications, and report upon the stability of a factory structure it was proposed to extend. At the time tenders had been received for carrying out the work. One of the first questions asked was the approximate floor load to be carried. The owners could not give this offhand, but advised later that it would approximate 125 lbs. per square foot. In the structure in question we found that the joisting and flooring specified would sustain with safety 85 lbs., while the beams supporting the joists were only good for 30 lbs. It is almost unnecessary to add that the factory in question has not been extended.

Another serious defect was that frequently, roof purlines, beams, rafters and board covering were too light, and owing, possibly, to changes in temperature, warped, twisted or shrunk to such extent that the felt, tar and gravel covering was damaged, causing leaks and entailing continual expense patching and repairing. But the maintenance is inconsequent as compared with the increased cost of operation in such a building from loss of power owing to shafting and machines being out of alignment; faulty workmanship from vibration of tools and inefficient light; and loss of production from belts slipping, and expensive and slow methods of handling stock in process.

In old time shop practice it was not appreciated that a few thousand dollars saved in the cost of construction, probably entailed double that expenditure annually in the operation and maintenance. The consideration seems to have been given entirely to the machines purchased; they must necessarily be the best possible—where or how they were housed, or how many hours they operated, were not of particular consequence. It was apparently sufficient that they would perform certain operations.

In modern shop practice the conditions are vastly different—a machine is purchased with the understanding that it will do a certain quantity of work per day if kept in continual operation. Due allowance is made for placing and removing work from the machine with the facilities of the modern work-shop, and the efficiency of the machine is estimated to be seventy, eighty or ninety per cent., according to the class of stock which it is handling. The machine hours are recorded as carefully as the operator's, and if the estimated results are not obtained, either the operator or the machine must be replaced, for the facilities of the modern work shop are such that the estimated results should be obtained with ease.

In modern work shop design no standard form of construction can be laid down since so many conditions are likely to affect it in one way or another; for instance, the situation of the property, transportation facilities, climatic conditions and the class of work to be produced. Thus each proposition must be carefully thought out and designed to suit the existing conditions.

The class of work to be produced has a very important bearing upon the design of building and its apparatus. For instance, it would be a most serious error to equip a foundry for turning out light work with heavy cranes, as they would necessarily be expensive and slow in operation.

Also in a machine shop arrangement, most careful consideration should be given to the class of work to be carried out; some are operating on heavy castings, others on comparatively light work, while still again are shops which have to do considerable machine work on light structural steel shapes. In the latter case a traveling crane may not be at all essential; an arrangement of trolley tracks and chain blocks may answer every purpose to even better advantage than would a crane. In some instances when the operations are short, the work is secured to the trolley and passed from process to process until completed before releasing. In the handling of this class of work it is necessary to eliminate to the fullest extent possible, building columns and overhead driving belts. In a one story building the steel truss roof and the independent electrical operation of each machine gives the desired result.

If in a two story structure clear floor space is required upon the ground floor, a common construction is to suspend the upper floor to the roof trusses ; while if the upper floor only is required to have clear floor space, the columns could be used below, the truss roof would meet the conditions above, and the machines could, if preferred, be belt driven from below.

The design most usually adopted for general machine work is a structure with a centre bay, ranging from forty to ninety feet in width, and two side bays, usually somewhat narrower. For heavy work all three are equipped with suitable traveling crane. The machine work of a lighter character is performed in the side bays, and the heavier work in the centre bay—the product to be worked up usually being received from the foundry located at one end of the above described building, and the goods delivered when completed to the erecting shop, located at the other end of the said shop, and also at right angles to it.

In shops turning out a lighter class of work, the travellers in the side bays referred to are occasionally omitted, and an upper or gallery floor constructed to receive lighter machine tools.

There are still other classes of light manufacturing which require neither cranes nor trolleys, but owing to the fineness and the particular care necessary in their production, require an especially well lighted shop. In such cases what is known as a saw tooth construction meets with favourable consideration. The name undoubtedly originated from the form of the roof, which much resembles a saw tooth, extending the full length or width of the building over each bay, the short side of the tooth is glazed and the long side roofed in the usual manner. Of course, this class of construction is restricted to one story buildings, but there is practically no limit to the length and breadth of the structure from a lighting point of view. Doubtless, the object of this form of roof construction is to give, throughout the shop, uniform distribution of light and, at the same time, exclude the sun rays. Designers have varied the form of saw tooth somewhat to suit local requirements, but by facing the glass due north and setting it at an angle of 25° to 30° from the vertical, there will be little oportunity for the sun rays to penetrate the shop during the usual working hours.

In the writer's opinion a modern structure of this design is more expensive to construct than an equally substantial building three or four stories in height, containing the same total floor area, for the reason that the foundations and roofings are more expensive per square foot of floor surface, against which, however, the walling is much less. Its possibilities of extension in any direction are limited only by the boundaries of the property. And it is also contended that for certain classes of work a structure of this design presents exceptional manufacturing advantages, in which event the initial cost of the structure is only of secondary importance.

The following features are, however, of the greatest importance in work-shop designing :—Good light, good air, steady power, efficiently distributed, solid foundations for buildings and machines, comfortable temperature, smooth floors, with adequate facilities for handling the stock from process to process, and the machines so arranged that the several operations from commencement to completion shall be in almost continual progression in one direction. It may be contended that such arrangement of machines is a detail of manufacturing convenience or economy. Such, however, is hardly the case, for the object of modern work shop design is undoubtedly to obtain the maximum production in the least time at a minimum cost, and the advantages of a modern work shop building may be frequently almost entirely lost owing to unnecessary handling of the product in the course of manufacture. And the designer may not necessarily be at fault, since he may not have had an opportunity of becoming familar wth the several processes of manufacture, or may have had only a very indifferent understanding of what was expected to be accomplished. For, to many manufacturers, the idea that any outsider could give any useful information respecting the machinery in their works, or suggest how to arrange the plant to handle the product in process to best advantage would seem preposterous.

Nevertheless the full advantage of the modern work-shop can only be obtained when the whole process of manufacturing is carried out in detail from beginning to end and the shops designed to house the arrangement as laid down. The mill engineer should be engaged long before it is proposed to commence building operations. He should be given, or placed in a position to obtain, the fullest particulars of what is being done and the manner in which it is done, and what it is further contemplated to do. From his natural ignorance of the business it becomes necessary that he diagram and work out every operation in detail to thoroughly understand it. In so doing he will, in all probability, notice features that may not possibly have received more than passing consideration in the past. And his asking an apparently absurd question has no doubt on more than one occasion indirectly attracted the manufacturer's attention to some shorter method or economy which had not previously been observed, and in just such accidental manner have many of the short cuts and economies which are now in general use, been observed and taken advantage of.

Having diagramed and determined the general procedure for performing the several operations of manufacture, the engineer should, with the assistance of the manufacturer and his superintendents, lay down the machinery in a manner to insure continuous progression in one direction as nearly as possible with the minimum amount of handling from process to process. This being accomplished all that remains is to design buildings to house the machinery as laid down, embodying, of course, to the fullest extent possible, the essential features previously cited. Without such preliminary planning it is extremely doubtful if the full advantage of modern work-shop design will be attained.

Of course, it may be contended that this is all very well in the case of designing new shops, but that it would be entirely different in the matter of carrying out extension to works presently in operation. The plan, however, holds good in either case.

In contemplating extensions to existing works, manufacturers very properly fear and try to guard against the consequent interruption to business. Extreme conservatism in this respect has sometimes led to the construction of a new and practically independent shop or factory, with the result that establishments may be found operating several departments or shops performing practically the same class of work, at, of course, greatly increased cost of operation, not only in the handling of goods between departments, but in the general management and supervision. More superintendence, foremen, labouring help, power, supplies, etc. being usually required than if the departments were concentrated under one roof. Therefore, in considering a re-arangement and extension of works, it should be assumed that the existing buildings contain practically no machinery and that the proposition is to arrange therein the most economical and efficient plant possible of the increased capacity called for. The plan when completed is compared with the existing arrangement and modified until a plan is finally determined upon that may be carried out with the least possible interruption to the existing works, and which when ultimately completed, will be modern and up-to-date in most respects, and economical to operate. The remodelling can then be commenced, carried out from time to time and the old plant will gradually evolve into a modern works of increased capacity without any serious manufacturing or financial inconvenience.

In connection with the construction of shop or factory buildings, there is a prevalent but mistaken idea with many builders that there is no particular occasion for accuracy or finish, and if the work is fairly substantial it should be sufficient. However, the accuracy, finish and detail specified should be closely adhered to for the reason that without entailing extra expense to anyone they add greatly to the appearance, stability and durability of the structures.

Special care must, of course, be taken in securing suitable foundations and adequate footing courses to carry the distributed loads which will be imposed upon them, and the walling must be well built and thoroughly filled with mortar as the least settlement in the foundations will surely damage the light brick curtain walls usually employed in the superstructure—if it does not affect it more seriously.

Usually there is nothing to be gained in making a foundation wall less than two feet in thickness, the contractors usually figuring that the additional labour building a thinner wall offsets the saving in material. Frequently, there is so little difference between the cost of lime mortar and Portland cement masonry that one is warranted in recommending the use of the latter, as it insures a tighter wall and better bond. In any event, the wall joints should be scraped and pointed inside and out with cement mortar, giving a comparatively smooth surface and tightness, thus minimizing the danger from frost or water penetration.

The use of the stone base course is largely a matter of preference. It certainly adds to the cost, but also to the appearance of the structure, and also has the advantage of giving a level surface upon which to commence the erection of the steel and brickwork of the superstructure.

In reference to the brickwork in the modern steel frame structures—the very thinness of the walls makes it important that they shall be especially plumb and true in every respect and thoroughly bonded together and to the steelwork, and flushed full of good mortar to insure tightness. Portland cement mortar is used to some extent, but good lime mortar will apparently meet most requirements.

Projections from brickwork are undesirable, but where essential, should be weathered on top surface and properly throated or dripped below. Much of the local brick is soft and porous and frequently scales off where severely exposed to the wet and frost, for which reason a dwarfed stone mullion is frequently placed at the lower corners of doors and windows. For the same reason it is also desirable to carry the masonry up (or use especially hard brick for the facing of walls) to a height of 30" to 3 feet above the general ground level.

The interior face of walls should be carefully jointed and made as smooth as possible to prevent dust accumulation. Window and door openings should be accurately and carefully spaced. It means no extra cost and adds greatly to the appearance of the building. Wherever possible the frames should be built into the walls, and in addition the joints scraped, caulked with oakum and pointed. Anent this matter of caulking: The writer recently heard it remarked that Canadians apparently desired their buildings to be hermetically sealed.

In so far as uncontrollable events are concerned, this is probably quite true for most structures are equipped with sufficient controllable vents in the way of doors, windows, etc. to give any ventilation required.

ROOFING.

In regard to the matter of roofing much could be said, as slate, terra cotta, concrete, iron, all find more or less favour, but are objectionable owing to their cost, weight, etc. The wooden board roof, covered with tarred felt and asphalt, is probably more generally used than any other, its low first cost being probably its principal recommendation, although when properly laid it gives good service. From an insurance point of view it is considered objectionable, some serious fire damages being attributable to the board and composition tarred roof.

The engineering department of the New England Mutual Insurance Companies recently issued a pamphlet favourably commenting upon a roof called 'Ferroinclace." Mr. Brown, vice-president of the Brown Hoisting Machinery Co., is credited with having thought out this construction. It consists of iron, specially corrugated into a dovetail form, and plastered upon both the upper and lower sides with a mixture of two parts of sand and one of Portland cement, the lower side containing a proportion of lime and hair. When completed the top surface is painted with two coats of a special non-drying paint, which renders the roof quite water-tight. The total thickness of the covering being about 1¼″. This form of roof is said to cost about twenty-five to thirty per cent. more than the ordinary board or plank and composition covering. It is contended that it resists fire well, but has a conductivity six to eight times that of 2″ spruce plank, from which it may be concluded that there would be considerable trouble from condensation, and unless the form could be changed to eliminate this it is a question if it would be very generally adopted.

In the matter of flooring it has been found that for ground covering something more rigid and durable than the 2″ or 3″ plank laid upon cerad sills was required. Brick and many forms of concrete have been used with varying results, but unless laid with particular care they are very likely to settle, crack and wear into holes, becoming finally very uneven ; in addition being objectionable from the operator's point of view in that they were hard and cold to work upon.

Another form of floor quite generally used at present is concrete foundation with nailing strips bedded therein. In some instances the tops of these strips were flush with the concrete, while in other cases the nailing strips in question projected 1½″ to 2″ above the concrete, thus forming, when the plank was laid, an air space between the concrete and the plank.

Still another form which the writer has used quite extensively and which he believes compares favourably in first cost, durability, rigidity and general service with any of the forms above mentioned; it consists of a 3″ cinder ground, well tamped to receive a 3″ tar and cinder foundation, rolled level, over which is then laid hot a vulcanite composition 1″ in thickness, into which are bedded 3″ sound hemlock plank, dressed one side and two edges, the rough side being well tamped into the hot vulcanite so as to give an even and true bearing. Toe nailing assists in laying plank true, but if the composition is properly made the adhesion of the plank to the vulcanite, after a few hours, is such that it is impossible to separate them without damaging the plank. The planking is in turn covered with two ply of tarred felt cemented at the joints, over which is laid, preferably at right angles or diagonally to the planking, a 1″ matched hardwood flooring, of narrow widths securely blind nailed.

A floor of this description is so rigid that all but the heaviest of machine tools may be erected upon and secured to it without other foundation. The composition prevents moisture reaching the wood, thus preserving it to a great extent from decay. The top flooring will, of course, wear out, but it can be easily renewed at comparatively small cost as there remains a good foundation of plank to renew upon.

To the writer's knowledge one such floor has been in service for the past six years in a machine shop—all but four or five of the heaviest machines having no other foundation than the floor above mentioned, and all machines are to-day perfectly rigid and true, and the top flooring is not appreciably worn excepting at some few points where the traffic is heaviest.

For upper floors where brick, terra cotta or concrete steel construction are not used, the 4″ plank flooring with 1″ hardwood top covering is probably more generally used than any other. The 2″ x 4″ flooring laid on edge, instead of 4″ plank, also finds some favour. This form of flooring is nailed through the side to the adjoining plank and to the running beams. The joints do not necessarily require to be broken on the beams and, therefore, there is probably less waste in laying a floor of this description than would be in the usual plank floor. In case of an extra heavy floor load or where an extra long span is required, 2″ x 5″ and even 2″ x 6″ may be used in the same manner. The material in question is usually dressed on four sides, one edge frequently being beaded or chamfered so as to give a neat ceiling effect to the floor below.

The writer has found it good practice to lay two ply of tarred felt, cemented at joints, between the lower and top flooring, for not only does this make it dust and oil proof, but frequently in case of a fire it prevents the water dripping down at many points on the machines below.

A floor of this description has been known to be flooded to a depth of 2″ with water from the sprinklers, and the only leakage to the floors below was at the walls and columns.

Although modern work-shop design is doing much to reduce the cost of handling stock in process of manufacture, yet comparatively little attention is given to the cost of receiving and delivering to first process of raw stocks, supples, etc. Of course, almost all manufacturing establishments are equipped with a warehouse or shed in a comparatively convenient locality adjoining the railroad, but in all probability the warehouse in question is located some distance from the point where the material will be required for the first process in manufacturing, and thus in nine cases out of ten entailing additional expenses for handling as the stock might probably have been placed in the first instance with little, if any, extra expense on almost the spot where it was to be used, or at least in such a position that further movement would be almost by gravity.

For instance, nearly all manufacturing establishments use coal to a greater or lesser extent, the usual procedure being to deliver it by team or barrow to the floor of the boiler house, from where every ton is transferred to the grate bars with shovels by the fireman. A coal handling plant would obviate this, but its first cost and operation are expensive, and it can therefore only be favourably considered in plants where large quantities of coal are being used; but in almost every case the boilers in manufacturing plants could be placed somewhat below the ground level or on an elevated runway erected so that the coal could be delivered by team into hoppers level with or above the boiler house roof, from which hoppers it would flow by gravity to the stokers, these in turn delivering it, as required, to the grate bars The hoppers referred to need not necessarily be large, two or three tons' capacity being sufficient in many cases.

It may be argued, of course, that such an arrangement entails increased capital expenditure and that if the fireman did not have the coal to handle he would be idle. Against this, however, it may be said that an intelligent fireman, with care and attention, can effect great economy in the use of fuel by noting the fluctuating demands for steam and preparing to meet them, and also by keeping his plant generally in condition to obtain the best results. If, however, he is required to transfer six, eight or ten tons of coal to his boilers per day, and in addition remove the ashes, it will be readily appreciated that he will have little time or desire to give thought to the matter of economies in the consumption of coal or maintenance of plant.

In connection with the handling of raw stock from cars to first process, the writer, some few years ago, in connection with some contemplated extension to a textile manufacturing plant,had occasion to observe the receiving and warehousing of raw stock and its further delivery to first process. The stock was being handled by the generally recognized method at that time, and although moved quickly, it required considerable labour. After some careful study a new method was thought out and a special form of warehouse designed for receiving this class of goods and some conveying apparatus provided for handling stock to first process. When the plant was completed and put into operation it was found that it effected a saving of six hundred per cent. in the cost of handling the stock to the warehouse and from the warehouse to the first process ; and what was of still greater consequence the operation was performed quicker and better.

A similar arrangement was installed subsequently in another plant and effected even a greater saving, principally, of course, because the operation originally in the second plant was more complicated than in the first.

Of course, such extensive economies in the handling of raw stock cannot be carried out in all classes of manufacturing, still in almost every instance there is opportunity for improvement of some description if the matter be carefuly thought out.

In still another manufacturing establishment it was found that an equally unnecessary expense was being incurred in the handling of goods after manufacture. In this instance all goods manufactured were transferred by teams to a warehouse some distance from the works, where they were stored, and later shipped to their destination. The expense of this double handling involving extra shippers, teams, etc. amounted to thousands of dollars per annum.

Reference is simply made to show that the locating and designing of the receiving and warehousing buildings for the raw and manufactured goods require as important consideration as any of the other buildings in a manufacturing plant.

Finally, there is the item of power. It must not be lost sight of in designing and arranging a modern plant, for outside of the economies to be considered in producing the power there are the losses in transmission to be considered, and whether water, steam or electricity be used the problem of distribution must be carefully thought out in order to obtain the best results.

The writer appreciates that possibly he has not treated the subject of modern work-shop design along the lines generally expected, and in explanation would say that with the movement in manufacturing to concentrate, conserve and utilize energy most efficiently in the production of goods, it became necessary to provide structures which would accommodate the appliances and features, necessary to this end. The flexibility of structural steel construction commended its almost general use as a frame work best adapted to meet the varying requirements and thus the building proper is really only incidental to or a detail in the general arrangement or design of the modern work-shop.