spection car. It would be desirable to make the observations always at the same speed, but this would involve the trouble and expense of special trains, and consequently they are made at various speeds. Under these conditions, a study of the results enables the following conclusions to be drawn:

(1) Vertical oscillations are influenced very little by the speed, owing largely to the action of the springs.

(2) Lateral shocks, on the contrary, increase very rapidly with the speed, but their relative importance at various speeds can be approximately

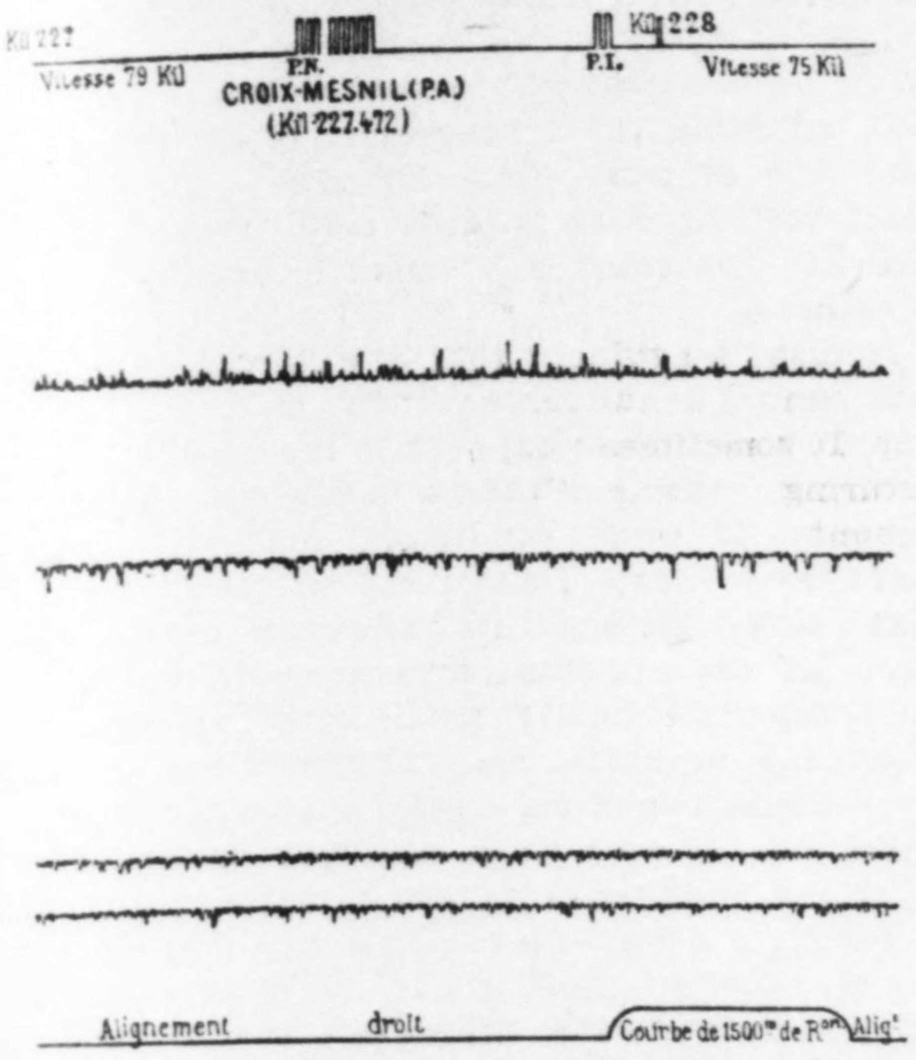

Fig. 2. Inspection Record of Well-Maintained Track.

reduced to that of a given speed by means of coefficients.

The car used for the inspection trips, and built especially for this service, is a four-wheeled car, 32 ft. long over the end sills, with a wheelbase of 18½ ft. Four long plate springs attached to the frame rest on the axle boxes. In the center is the registering apparatus, and at each end is a large open platform, protected by the roof and sides, the rear platform being separated from the recording room only by a glass partition, so as to allow of a good view from the interior in case of bad weather. At each side of the recording room is a bay window, with a seat, which arrangement facilitates the work of reading the mile or kilometer posts and noting such special points as stations, junctions, tunnels, etc.

Complete registration would include six movements: (1) Vertical movements above and below a datum line; (2) Transverse movements to right and left of the center line; and (3) Longitudinal movements before and behind a transverse datum line. The latter, however, are due rather to the tractive effort than to the condition of the track, and it is sufficient to record vertical and transverse movements.

It was considered that the simplest means of obtaining the record was to employ pendulums, as was done by Mr. Sabouret in 1890 to deduce from the movements of a locomotive when running the intensity of the forces exerted upon the track. A mass able to oscillate from its position of equilibrium shifts from this position when its support sustains a shock. It returns to position by a series of oscillations, but the initial movement is a measure of the intensity of the shock. A difficulty in registering a series of shocks at short intervals, as in this case, is to ensure that the mass returns to its normal position quickly enough to prevent the interference of successive shocks. To provide for this, it is necessary to use a stop which allows the weight to move only to one side of its normal position. It is finally necessary to so design the suspension of the weight as to prevent unimportant and rapidly deadened displacements.

Mr. Sabouret, who experimented only with lateral shocks, realized this last condition by the use of short and heavy pendulums. In the track inspection apparatus, however, for registering the same shocks, the pendulums are made a little lighter, but have their oscillation shortened by means of springs. Then by varying the stiffness of the springs, the maximum extent and duration of the oscillations can be reduced to limits appropriate to the car on which the tests are to be made. For registering the vertical shocks, the same principle is used; lead weights oscillate around horizontal axes, striking against a horizontal frame.

The various oscillations are recorded on a sheet of paper traveling at constant speed, and on which are marked (as the car passes) the kilometer posts and special points. It is then possible to determine the exact speed of the train between two posts, the exact point where a shock has been felt, and to see if this point corresponds with any apparatus in the track, such as a frog, switch, etc.

The apparatus used is shown in Fig. 1. The two vertical pendulums A A oscillate on shafts B B, and strike against the central frame C C, which is made in two parts to prevent the transmission of shock from one pendulum to the other. The springs D D, whose tension is regulated by set screws E, reduce the travel of the pendulum. The oscillations are recorded by the pens F. At the upper part are two horizontal pendulums G G oscillating around shafts H H, held in equilibrium by the springs J J, and striking against the frame K. As the shocks are very slight only a single frame is used. The recording is effected by the pens L L, which are carried by levers balanced on fixed axes, so that they are not affected by lateral shocks. A pen M, operated by a rubber bulb by hand, marks the kilometer posts, stations, tunnels, etc. The mechanism for feeding the roll of paper consists of a magazine roller N; a collecting roller O, operated by a spring, and a regulating roller P, controlled by an escapement. The screws Q are for attaching the apparatus to the table in the car.

In the interpretation of results, especially those of the lateral shocks, it is necessary to remember that the car does not follow exactly the course of the track. Consequently, certain defects (especially slight irregularities in line) may more or less escape being recorded; but this applies to all parts of the line, so that the general record is sufficiently exact. On the other hand, it may be taken for granted that every slight shock recorded corresponds certainly to a defective point in the track. In several cases when the section foremen have failed to at once find the cause of certain shocks reported to them after an inspection, they have been ordered to make a more careful examination, which has brought the cause to light, thus showing the value of the records.

After several trips on a certain piece of line at different speeds the limit of admissible oscillation is determined and is marked on the charts. In passing curves, the lateral oscillations are made more difficult of interpretation, as the speed not only increases the intensity of the shocks, but also falsifies the records given by the apparatus,

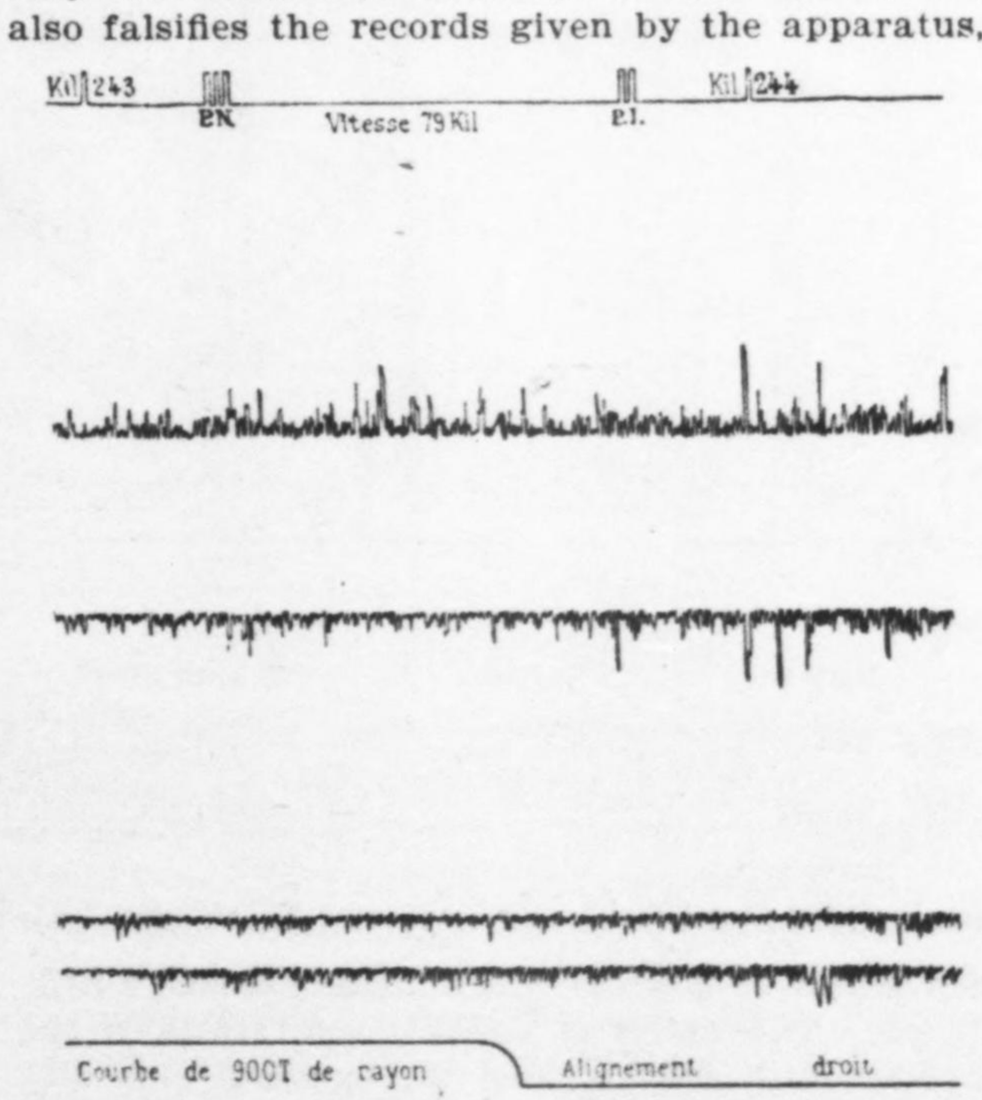

Fig. 3. Inspection Record of Track in Poor Condition.

the pendulums having a tendency to move by centrifugal force. A sufficiently exact determination, however, can be made by watching the motion of the two pendulums. If their oscillations appear to be equal it may be assumed that the effect of centrifugal force is balanced by the superelevation and that the records can be taken as equivalent to those on straight lines. If, on the other hand, the oscillations appear to be greater towards one side or the other, it may be presumed that they are increased by the inclination or the centrifugal force, which must then be taken into account in interpreting the results.

Fig. 2 is an example of a record on good track, and Fig. 3 is an example of a similar record on track in poor condition, both sections of track being laid with 60-lb. rails 25 ft. long, with 11 ties to the rail. The speed is the same in both cases,

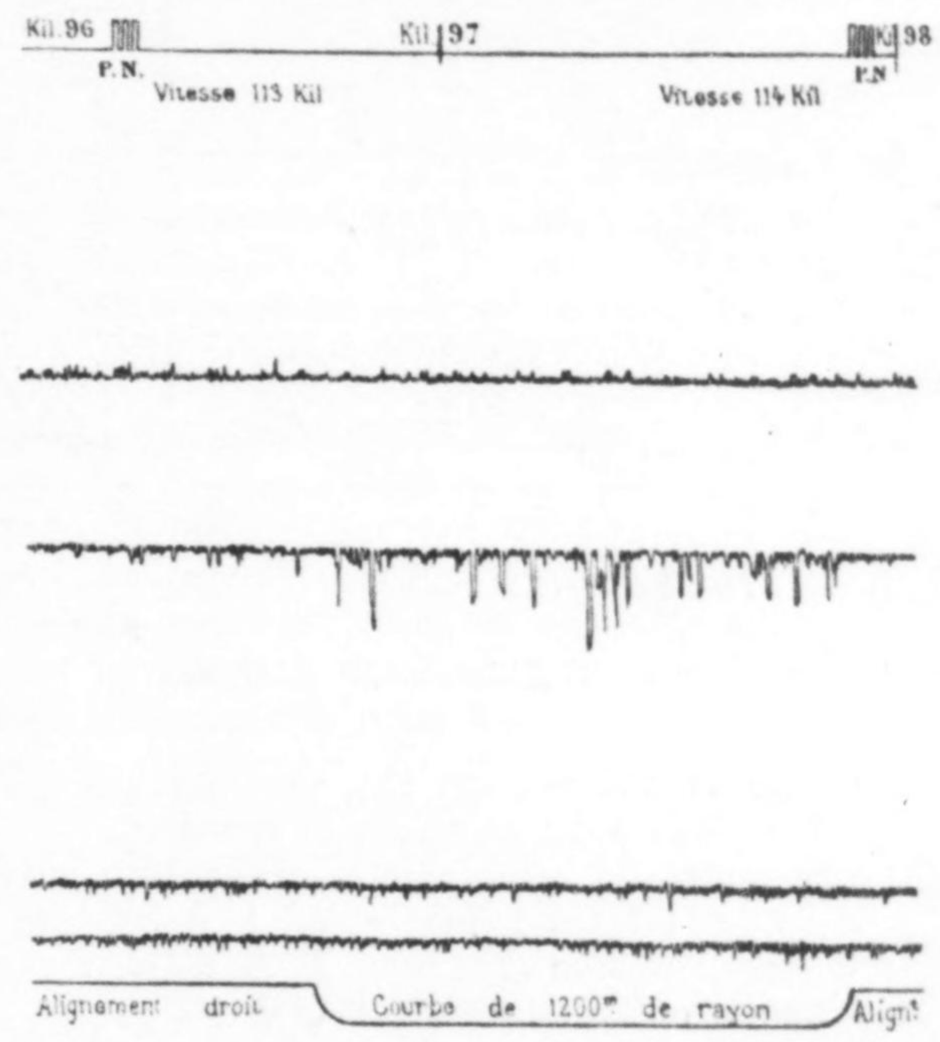

Fig. 4. Inspection Record of Track on Curve, Showing Influence of Centrifugal Force.

46 miles an hour. Fig. 4 is a record in which the lateral indications are exaggerated by centrifugal force on a curve. This record was made on 90-lb. rails 39½ ft. long, with 16 ties to the rail length.

All the lines carrying high-speed traffic are usually inspected at the beginning of the season. The charts are examined, compared with those of previous inspections, and then sent to the roadmasters, calling their attention to points where the condition is not satisfactory. This enables them to concentrate their work where it will best facilitate the traffic, and the charts are then returned to the maintenance-of-way department with an explanation of the nature of the defect corresponding to each point indicated, and the steps taken to remedy it. Special inspections are also made, as, for instance, when complaints are made of shocks or hard riding of trains on any piece of line. This system has been found very advantageous.

A NEW DESIGN OF TRUSS WITH PIN AND RIVETED CONNECTIONS.

In the design of truss bridges there is a growing tendency to dispense with pins and use riveted connections, except in cases where the pin-connected type of construction presents its special advantages. The accompanying cuts represent a radical departure in truss design, in which both riveted and pin connections are employed. This type of truss was developed by Mr. J. W. Schaub, M. Am. Soc. C. E., 1650 Monadnock Block, Chicago, who has been using it since August, 1901. It has been adopted by Mr. E. Fisher, Engineer of Bridges and Buildings of the Missouri Pacific Ry.; Mr. H. G. Kelley, Chief Engineer of the Iowa Central Ry., and by Mr. C. D. Purdon, Chief Engineer of the St. Louis & San Francisco Ry. For all of these Mr. Schaub has prepared plans for bridges as Consulting Engineer. The particular bridge illustrated is one for the St. Louis & San Francisco Ry.

It will be noted that the truss is of a Warren type, with a combination of pin and riveted connections; the bottom chord is entirely pin-connected, while the top chord has pins only in the end joints. The web members are partly pin-connected and partly riveted. The design is claimed to present many advantages over the usual forms of pin-connected spans, and serves as a link between the short riveted spans (under 150 ft.) and the long pin-connected spans (over 200 ft.).

The salient features of this design as outlined by Mr. Schaub are as follows:

(1) The absence of all adjustable members.

(2) Truss members subject to a reversal of stress are riveted at their connections, which per-

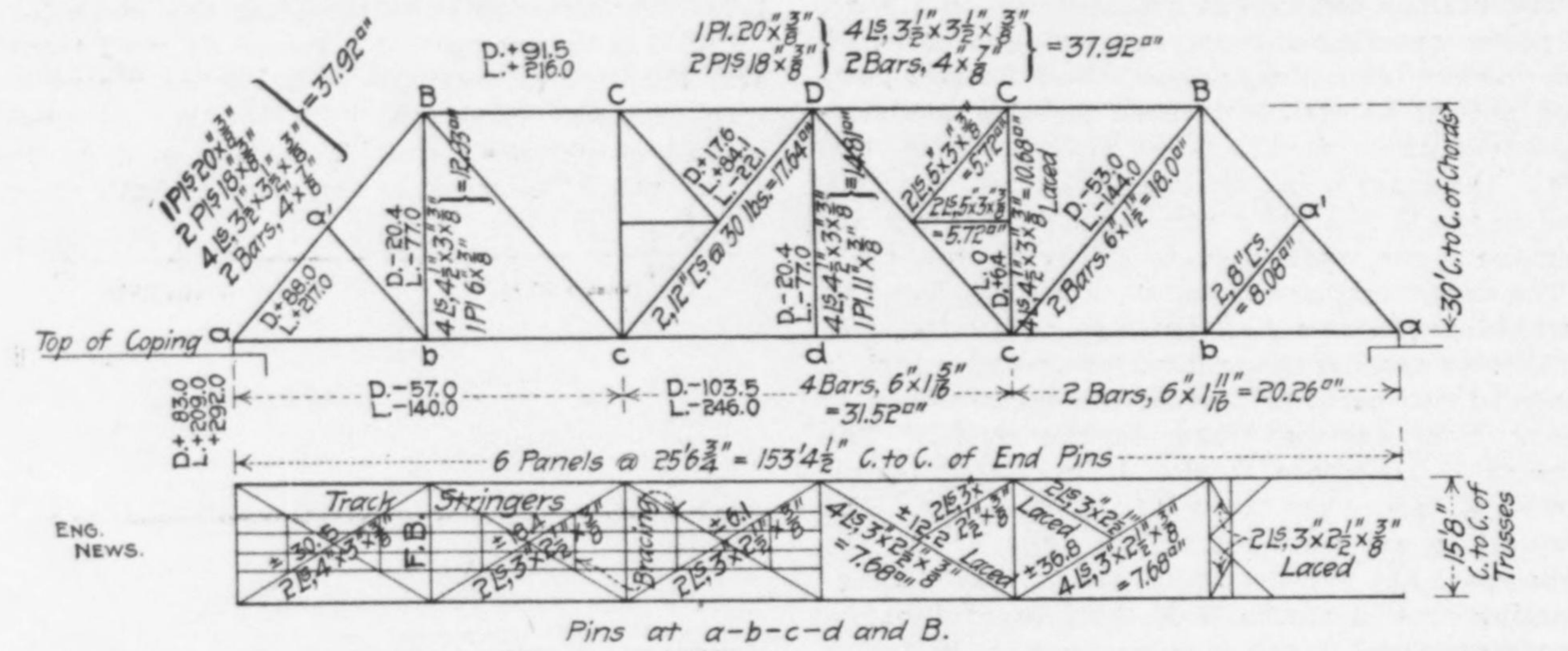

FIG. 1. TRUSS WITH COMBINATION OF PIN AND RIVETED CONNECTIONS; ST. LOUIS & SAN FRANCISCO RY.

J. W. Schaub, M. Am. Soc. C. E., Consulting Engineer, Chicago, Designer.
C. D. Purdon, M. Am. Soc. C. E., Chief Engineer, St. L. & S. F. Ry.

mits of no movement on the pins during the change from one kind of stress to another.

(3) The top chord being riveted throughout permits of no articulated joints, which is a very important consideration in case a derailed train should knock out an intermediate post.

(4) Facility in erecting the main trusses with

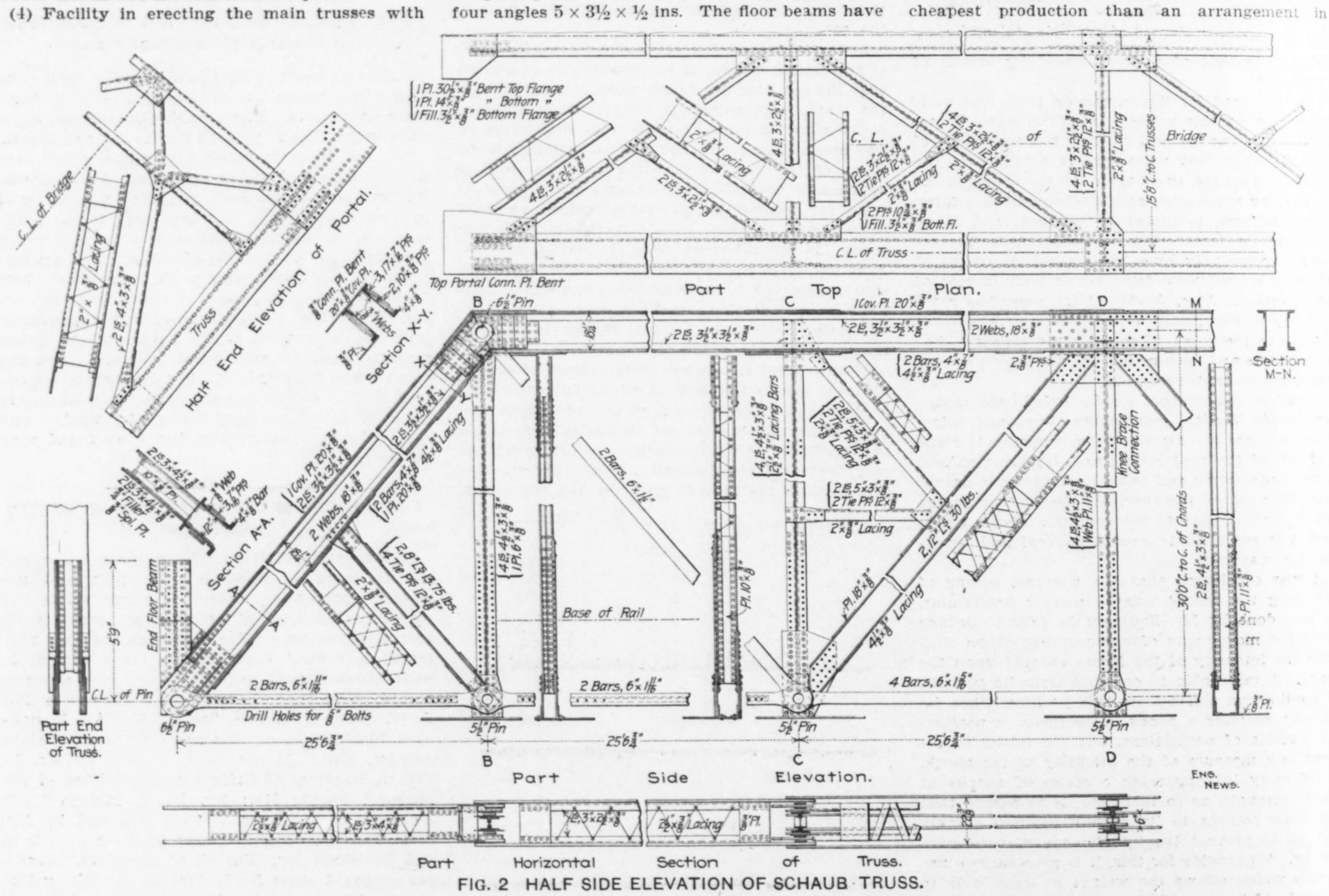

FIG. 2 HALF SIDE ELEVATION OF SCHAUB TRUSS.

a derrick car or a traveler. After the floor system is in place, the web members are raised, one at a time, and bolted to the floor beams. The top chord sections are placed in position last; and at no time is it necessary to hold up more than one truss member to make any connection in the field. It is true that the field work costs more, as compared with the usual pin-connected designs, but this is due to the field riveting.

(5) Economy in design, owing to the narrow limits to which the top chord can be confined, making the entire bridge narrower, in addition to making the top chord sections themselves narrower, as compared with pin connections. The saving in weight in the main trusses is about 3% for a 150-ft. span.

The bridge illustrated carries the St. Louis & San Francisco Ry. over the Meramec River, and consists of two through spans of 153 ft. 4½ ins. The trusses are 30 ft. deep and 15 ft. 8 ins. apart, c. to c. The general design and composition of members are shown in Fig. 1. The track stringers are plate girders with web plates 38¾ × ⅜ ins. and four angles 5 × 3½ × ½ ins. The floor beams have web plates 47 × ½ ins. and four angles 6 × 6 ×13-16 ins. The material used is soft steel, except that medium steel is used for eyebars, pins and rollers. The assumed dead load is 2,100 lbs. per lin. ft. (465 lbs. for track). The assumed live load consists of two consolidation locomotives (Cooper's specifications, type E-40), followed by a train load of 4,000 lbs. per lin. ft. The maximum moment and end shear in track stringers and floor beams are as follows:

	Track stringer ft.-lbs.	Floor beam ft.-lbs.
Maximum moment	175,500	[illegible]
Maximum end shear	31,000	[illegible]

The details of construction of the truss are shown in the half elevation, Fig. 2, and the cross-section, Fig. 3.

THE PLANNING OF FACTORY BUILDINGS AND THE INFLUENCE OF DESIGN ON THEIR PRODUCTIVE CAPACITY.

By Hugo Diemer.*

In designing factory buildings, considerations of utility and economy must come first, and architectural effects must subserviently adapt themselves to these prime requisites. The building must be designed with regard to intake and output, adapting the arrangement to the equipment and flow of work, following always the lines of least resistance as regards both losses in transmission apparatus and losses in activity of live operators.

It must be evident that a wide variety of output cannot be advantageously built in a single shop. It sometimes happens in the machine-manufacturing business that a single shop must, on account of trade conditions, manufacture both light and heavy machinery, or machinery and light detail fittings. In such cases careful planning of departmental arrangements, equipment, and organization, is particularly necessary, to keep the separate costs of production of each type distinct, and at a price reasonably near the minimum for each class. Again, it has been found that the building of groups of parts representing a complete organ of a machine, in a single department, is often more likely to bring about the cheapest production than an arrangement in which all pieces travel through the whole shop, each distinct class of machine-tool work being grouped by itself.

The proper arrangement of departments, and of machines, with regard to each other, depends on statistical knowledge of the predominant paths of travel of the material in process of manufacture. Such information collected by actual ob-

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servation can alone determine to the best advantage, also, the location respectively of rooms for stores, stock, tools, grinding, etc.

Except when specific reasons to the contrary appear, the cheapest building is to be constructed in which it is physically possible to do the work well. A building must provide shelter from weather, afford good light and ventilation, and must be able to resist all strains to which it is subjected by equipment and employees, besides offering reasonable resistance to weather and conflagration. Beyond these considerations any additional elaborations are only excusable when charged to the advertising account.

For psychological reasons it is desirable that the building present a pleasing appearance. Hence, any architectural artifices are to be commended that will relieve monotonous continuity, such as in the case of a long building, the use of projecting pilasters which also add to the rigidity of the structure, or the use of external projections for elevator shafts and stairways, if such a location be desirable. Where a low building with central gable and single gallery is used, it may be desirable to have elevators and stairways at the inside of the gallery on account of their thus feeding a wider territory with a shorter amount of walking and hauling than they would if placed at the outer walls.

It is important that as great floor space as possible should be visible at all times. Hence, all angles, "L's," "E's" and "H's" should be avoided in favor of the plain, long, rectangle. The same consideration of visibility and the avoidance of unnecessary walking or elevator riding, argues for the single-floored structure as against multi-floored buildings. Even the single gallery is best avoided, as it forms a more or less isolated area not readily visible, and increases walking and trucking. "Avoidance of unproductive travel" demands a minimum of passage ways, which passages should always be under the close supervision of watchmen who must note all wandering clerks and workmen, and who must be so informed as to the employees and their duties, that they may be able to observe and report illegitimate or aimless wandering.

The single-floored building is often to be preferred even where land is costly. The lower cost of the building, the reduced fire risk, and above and beyond all, the greater productivity per unit of floor area, may more than counterbalance the interest on the first cost per unit of floor space. Moreover, a large tract of well-located land is bound to rise in value.

The site selected as well as the shape of the building, must be such as to allow for expansion. This demands the possession of land allowing for the expansion in length of the rectangular building, and such lateral expansion in the way of additional buildings, as may in time be needed.

A well designed building will provide facility for enlargement, maintaining the same balance of floor area. This demands the recording of all increases of area whenever they have become necessary, and the use of such data in designing new buildings. It has been aptly stated that a well-designed factory building or set of buildings should be as flexible and adaptable to enlargement as the "unit" system of filing cabinets.

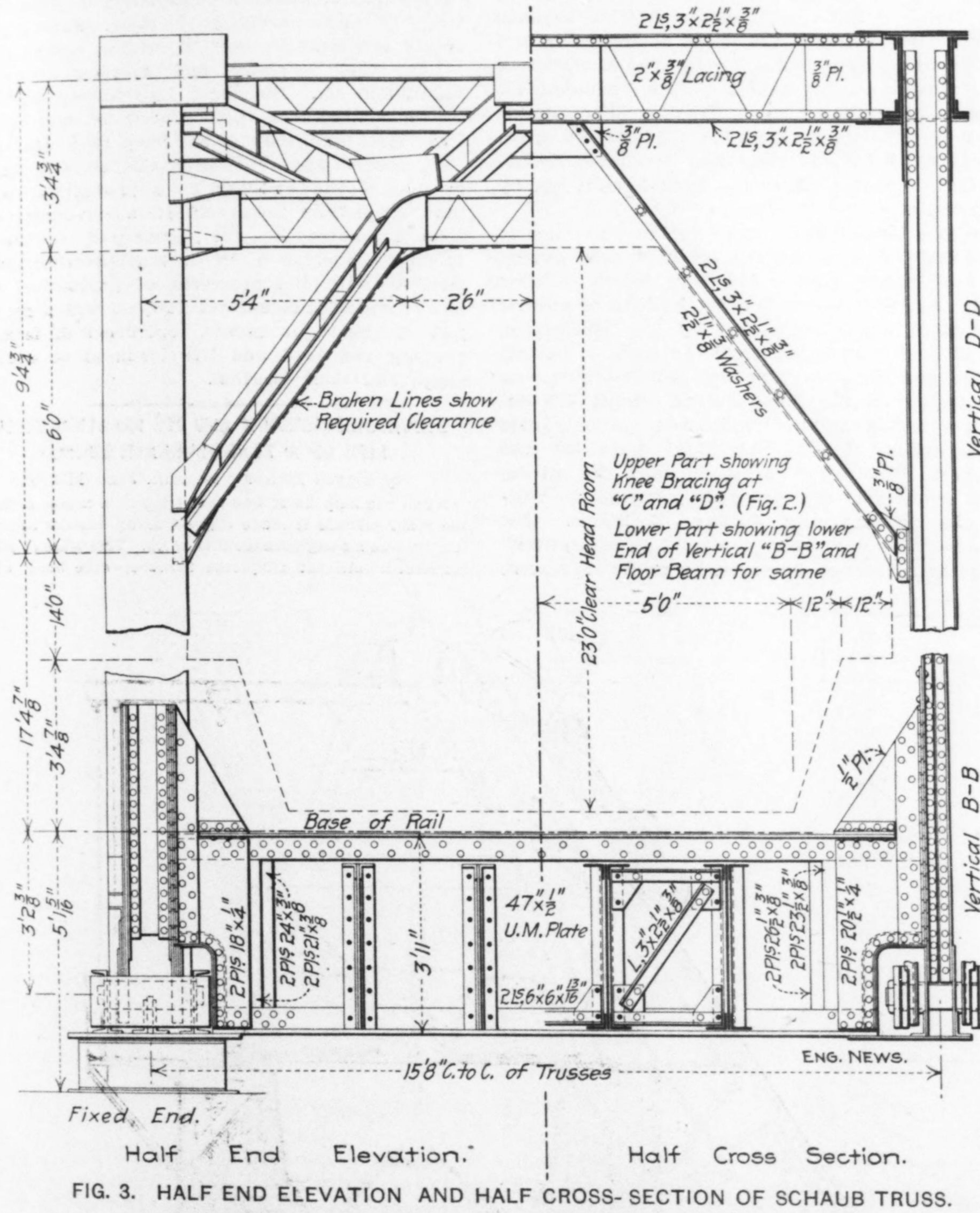

FIG. 3. HALF END ELEVATION AND HALF CROSS-SECTION OF SCHAUB TRUSS.

The departmental organization of an establishment should be carefully analyzed and if necessary, revised, before a new building is erected. The location of departments so as to secure minimum travel, demands careful study, as does also their arrangement to secure the easiest flow of work without interference of currents.

The proper location of the rooms for raw material, partly finished material, finished parts, finished complete stock, wash rooms, lavatories, locker rooms, tool room, grinding room, etc., should not be deferred until after a plan has been adopted, since their proper location will have a decided influence on the cost of production.

In the shop portions, room must be provided, without crowding, not only for all machinery, but for all materials in process of manufacture. Sufficient room must be allowed to provide convenient access to all parts of a machine, and for the removal of any machine whenever necessary. Sufficient area must be given for the storing of as large a supply of working material and finished material as may be necessary, without interfering with the passageways. The open areas must be wide enough to permit the passage of two trucks in the aisles and for the sidetracking of trucks around machines. A good truck system includes many more details than the providing of occasional turntables. A truck system involving the retention of the material in the trucks, with as little unloading and reloading as possible, and with as little hauling of empties as possible, is an important feature, and one deserving attention in any establishment. It involves the building of a considerable number of trucks, and departmental supervision, but is likely to result in economy.

A noticeable defect in the great majority of factory buildings is the large amount of vibration. A careful study of the uses to which the building is to be put, and the location of its equipment, could almost wholly prevent this defect, whose evil results are far greater than is generally appreciated. Vibration causes undue wear and tear of machine tools, and interferes with correct tool work, besides seriously affecting the efficiency of all employees, whether they are engaged at manual or mental work. Here again the folly of adopting some architect's "ready-made" plans become apparent. Too often the designer's knowledge of the work to be done in the factory is practically nil.

The wind loads and snow loads are wholly secondary to the live stresses due to shafts, countershafts and moving machines. Economic production demands that the building fit the machinery, whose location in turn, as previously stated, depends on the flow of the work. Liberal foundations are to be provided for all heavy machines. A cushion of asphalt below and around the foundation has been used to good effect as an additional vibration destroyer.

Economy demands the location of the source of power and heat at the side of the building, somewhat nearer the end which is likely to be elongated. It should be provided with easy means of access for delivery of fuel and for removal of ashes. The use of sloping trestles is often an advantage in bringing cars to the level of upper floors or platforms in the case of power-plant, foundry, etc. A system of out-door tracks and of out-door cranes should be considered and provided wherever, on investigation, it would appear to be an economic move.

The general form of the framing of the building designed to conform with the ideas suggested will not include many varieties. It may have the central gable with sloping sides, the central gable with saw-tooth construction on the sides, or the entire shop may be of the saw-tooth roof construction. The central gable gives a more pleasing architectural effect than the saw-tooth roof over the whole building.

It is not the aim of this article to take up such features of building construction as have not directly to do with the productive output; hence, it will be unnecessary to treat of such matters as materials for roof covering, framework, side walls, painting, etc.

In designing a building it must be borne in mind that while it must be so planned as to place to greatest advantage the machinery of manufacture, there will always be a great deal of work that depends upon human attendance, and that it is just as important that the human machinery be provided with such surroundings and arrangements as will make it the most efficacious. Such arrangements are too often looked upon as philanthropic or advertising measures, when in fact, they are part of the productive equipment. The output of man, as a machine, is regulated first