Before Dr. Cartwright invented the power loom in 1785, the cotton-spinning factories had attained quite a considerable growth in the Lancashire district of England. When the cotton loom came into practical use, weaving was carried on in the homes of operatives, up to the time when, with the increase in cotton weaving and the advent of the power loom, it developed upon the progressive operator to branch out into a new plant and set up a few power looms, as a weaving establishment. This naturally was a one-story building, and in time was designated as a “weave shed.” Thus was commenced a system in textile manufacture which became popular, and is so today in England and on the continent. The spinning factory produces the yarn and the weave shed the cloth.

As these weaving companies changed from plain to fancy and colored weaving, and increased the width of the weave sheds to gain greater area, some method of roof lighting became necessary. Thus necessity, the mother of invention, produced the saw-tooth form of roof skylights for lighting the center of the wide one-story buildings. The English and continental manufacturers were not long in appreciating the value of this method of lighting. The first use was on machine shops making cotton machinery. Today they are found on all kinds of manufacturing plants.

The principle in this so called “saw-tooth” form of skylight is the focusing of a strong north light upon the work in process. This is secured by the greenhouse type of sash, applied to one side of the saw-tooth and exposed to the north light, the glass being set at such an angle as not to admit the direct rays of the sun. This type of sash reduces to a minimum the wood work, and thus minimizes the obstruction of light and the casting of shadows. The result is a practically continuous window of glass, which gives a far greater lighting area than wall and windows, or than skylights placed in the usual manner at intervals.

The skylights may run across the building, or lengthwise of the building, so that the glass may face to the north. Placed across the building, they are somewhat simpler in construction and thus less expensive.

**METHOD OF CONSTRUCTION**

Today there are two constructive designs in applying these skylights; one English and the other American. The English design is in the true form of saw-tooth; the American, in the modified form, or semi-saw-tooth flat-roof design. The angle of the glass is designed by some at 60 degrees, but when the sun is in the zenith it will shine through these skylights. This matter has been lost sight of, as one of the leading features in the principle of saw-tooth skylights is the elimination of the direct rays. For the South the writer has used 77 degrees and for the North 71 degrees.

In my later designs I have reduced the wide flat roof space between the skylights, and somewhat reversed the modification, returning more closely to the English system, but at the same time preserving a

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*Extracts from a paper read at the December meeting of the American Society of Mechanical Engineers.*
narrow flat roof between the skylights, varying in width from 24 to 48 inches, according to circumstances. (See Figs. 1, 2 and 3.) The flat gravel roof was then reduced from 3/4-inch to 3/4-inch pitch to the foot, in order to convey the water away in the usual manner, and avoid the building up of such high forms as would be necessary with 3/4-inch pitch.

The height of the glass is based entirely on the class of manufacture and amount of light required. Four, five and six feet have been my usual basis to work from in determining the size to use. Four feet high, every 20 feet, is good for general use. Five feet is used for special cases, and openings are provided in the horizontal metal for letting out the water as it collects.

The double glazing is necessary for some manufacturing plants in the North, but only single glazing is used in the South. The flat gravel space between the skylights and the method of flashing are also detailed.

One element of weakness in the construction of some roofs of this type is that the galvanized iron is continued down onto the roof and becomes a part of the flashing. True flashing, and the best, should be of about 10-ounce zinc, running at each end wall.

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In the year 1900 the writer was called upon to design, in connection with the planning of a Southern cotton factory, the weave shed for weaving pattern fabrics. In adopting the saw-tooth skylight I had to eliminate all cross timbers to avoid the casting of shadows. Appreciating the value of north light, and wishing to avoid any direct sun rays, I set the sash at an angle of 77 degrees. This angle, which brings the sash only 13 degrees from the vertical and therefore not at a great inclination, led to the belief that the elaborate trussed form in framing these skylights was entirely unnecessary to resist this small amount of thrust. I therefore adopted the tie-rod as the lower chord spanning from column to column, anchoring at each end wall.

FIG. 3. DETAIL OF AMERICANIZED SAW-TOOTH SKYLIGHT FOR FACTORY ROOFS

In the year 1900 the writer was called upon to design, in connection with the planning of a Southern cotton factory, the weave shed for weaving pattern fabrics. In adopting the saw-tooth skylight I had to eliminate all cross timbers to avoid the casting of shadows. Appreciating the value of north light, and wishing to avoid any direct sun rays, I set the sash at an angle of 77 degrees. This angle, which brings the sash only 13 degrees from the vertical and therefore not at a great inclination, led to the belief that the elaborate trussed form in framing these skylights was entirely unnecessary to resist this small amount of thrust. I therefore adopted the tie-rod as the lower chord spanning from column to column, anchoring at each end wall.

LATEST SKYLIGHT DESIGN

Fig. 3 illustrates the various details of my latest skylight design, and it will be noted that both the double glazing and single glazing are represented. I would draw particular attention to the details of the metal bars. The bars and the bottom of the glass are provided with small gutters for collecting any condensation, and openings are provided in the horizontal metal for letting out the water as it collects.

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It is not a great expense to hire cheap labor to shovel out this snow, as through our whole winter period heavy storms are only occasional. The cost of shoveling out the snow is a very small expense as compared with the enhanced value that fine lighting gives to the production of a plant. It must be conceded that with a monitor skylight in a drifting storm, the vertical side would resist the snow and pile it up, and naturally bring about the same result as with the saw-tooth. Right here the English system would show its serious defect. The advantage of the flat roof is that it spreads out the saw-tooth into a wider area and the snow cannot pile so deep as in the "V" form.

ELABORATE TRUSSING UNNECESSARY

Fig. 4 illustrates the elaborate trussed form of framing, Fig. 5 a similar form in reinforced concrete. I believe it is en-
crack in the roofing higher up than the highest point of the tin-work that runs up under the gravel roofing.

**VERTICAL SASH**

Some designs have the sash set vertically. This is uncalled for, as, with the same height of glass, if the sash is set at an angle, the area of direct rays of light is increased. There is also less length of slant for the back of the skylight, and thus less roof area to cover. This vertical design was used for the purpose of hanging the sash with weights or on a pivot. The slant from the vertical is so small that there is no trouble from the weather beating in.

**SASH CONSTRUCTION**

The sashes are constructed either of wood or sheet metal. If of wood, the glazing is with putty; if of metal, the glazing is done without putty and bars are formed to take care of condensation. With reference to wood versus metal skylights, and what metal workers are doing under contract at the present time, the following is a quotation from a letter on the subject: "We have a contract at present for changing over four saw-tooth skylights, about 200 feet long by 15 feet glass opening, from wood construction to metal construction; also for two saw-tooth skylights that we are erecting in metal. These are about 90 feet long by 10 feet 6 inches glass measure. Heretofore the saw-tooth skylights for this company have been built in wood and a departure was made in favor of metal."

**VENTILATION**

The subject of ventilation, in connection with this particular class of skylight, has gone through changes along with the vicissitudes of the skylight itself. When these skylights were first introduced on weaving sheds of cotton factories, no ventilation was provided. Later, as the skylight manufacturers developed new inventions, the Louvre ventilator was adopted and used in the end of the saw-tooth, as a substitute for round windows, which may have been hung on swivels. Next followed the usual style of galvanized iron ventilator, common in metal skylights used on other classes of buildings. The latest method is to hang one-half the length of the glass at the top and control by the usual quadrant for opening at any angle. These are good in periods of clear weather, and in connection with the roof ventilators give a very good current of air. In stormy weather these side lights must be closed, and the ventilation is taken care of by the Louvre and the roof ventilators.

**ROOFING**

The most approved practice for covering the back of these skylights is some form of asphalt roofing, the method of applying depending upon the angle, or slant, of the roof. Those which have a slant of 4 inches to 1 foot can be covered with the usual asphalt felt roofing and covered with gravel, the same as a flat roof. If the slant is greater, then the two upper layers of felt should be applied in what is called prepared gravel asphalt roofing. The flat spaces between the skylights can be of the usual coal tar, felt roofing, and gravel, unless one prefers to have it all asphalt at a slightly increased cost.

Saw-tooth skylights do not add to the architectural beauty of a factory building, and therefore I have studied to keep them down to a reasonable height, and at the same time make them high enough to give the amount of light required.

**REINFORCED CONCRETE**

The use of reinforced concrete in factory buildings suggests its adaptability to saw-tooth skylight construction. Fig. 6 illustrates how this Americanized saw-tooth form can be very simply constructed in reinforced concrete and embody in it all the features necessary.

**APPLICATION**

Saw-tooth skylight construction is not only adapted to cotton factories but to factory buildings, machine shops, and for all kinds of manufacturing plants, where better lighting is required than can be obtained from side windows. It is superseding the common monitor roof, and is especially adapted for use over erecting rooms and crane rooms of machine shops. It solves the problem of the one-story flat-roof machine shop and factories, where this style of construction is desirable and wide buildings are required. In shop economics, and with the extensive area of modern plants, the monitor skylight compels an excessive length in buildings, while the saw-tooth skylight admits of a proportionally greater width and length, hence giving a more compact arrangement of the shop departments and a consequently greater available area of floor space.

Where land is valuable, it is applicable to the two-story shop or factory, if special provision is made for lighting the first story. My latest application to a machine shop was a design for the John Thomson Press Company, of an 80-foot shop erected at Long Island City, in 1905, while I was acting as consulting architect. This width of 80 feet had two rows of columns, thus practically three 25-foot divisions. The manufacturer's general plan was to use the two outer divisions of first story for heavy tools, the center division for tool room, storage, etc., and the second...
story for light machine tools. Over this second story, the introduction of the saw-tooth skylight is applicable and very practical. Its practical value is in the improved arrangement of tools and benches. Instead of the benches being run around the room against the walls, they can be run across the room, benches and tools alternating down the length of the shop, according to the nature of the product.

With this system a greater production is sure to follow and with the strong roof light, a higher degree of workmanship.

From a paper on the same subject read at the same meeting by K. C. Richmond, we extract the following:

ANGLE OF THE GLASS

The purpose of the saw-tooth form of lighting being, in most cases, to provide direct skylight in large quantity, and at the same time to avoid direct sunlight as far as possible, it follows that north of the tropics the saw-tooth windows must face nearly north, and the angle of the sash with the vertical be made dependent on the latitude of the location, the angle increasing the farther north we go. In the latitude of New York, about 41 degrees, this would mean an angle of only 17 to 18 degrees, to keep out the sun in the longest summer days, were it not for the small projecting cornice above the window, and the internal stool or gutter at the bottom. These projections enable us to make the angle of the glass with the vertical greater than we otherwise could do, and with the form of setting and trimming frequently adopted, angles from 25 to 30 degrees have proved satisfactory in practice in New York and New England. The angle of the glass with the vertical could be made much greater, and still keep out direct sunlight, if the cornice above the windows were extended, or a screen or barrier run along the crests of the saw-teeth. A very interesting modification of saw-tooth lighting on the above line has been made by Willard T. Hatch, a member of the society, in the treatment of foundry roofs, where he has placed the glass skylights on one side only of the successive ridges of the roof, and used the continuous ventilating monitors at the peak of the ridges as a screen to keep direct sunlight off the glass, thus making the angle of the glass with the vertical much greater than would otherwise be possible, at the same time getting the benefit of the brighter light of the upper sky in much greater degree than would be the case were the same area of glass placed more nearly vertical.

Where the angle of the glass with the vertical is made greater than a theoretical consideration of the latitude permits, for the reasons above noted, and the windows face the north, it follows that at seasons when the sun rises and sets north of the already determined by other considerations, we can avoid in a large measure the direct light of the late afternoon sun in summer by placing the building so that the saw-teeth will face from 5 to 15 degrees east of north, and still not have trouble from direct sunlight before bell-time in the morning.

FLASHING AND DRAINING

The flashing and draining of saw-tooth roofs have given trouble at times. The
great length of flashing in the valleys between the saw-teeth gives opportunity for much expansion and contraction, and the piling up of snow in the valleys, with a relatively warm roof melting it on the underside, gives a chance for water to work up over the lower flashing, unless the same is of ample height and very carefully put in, and provision is made for promptly carrying off the water from the melting snow. Where the saw-teeth run across the building, the roof is often pitched from the center ridge to both sides on a slope of a quarter to a half inch per foot, and the water carried off in conductors which run down on the inside or the outside of the outside walls. Outside conductors have proved very undesirable in New England on account of the water freezing as soon as it has passed from the warm surface of the roof to the cold outside conductor. The result is a great mass of ice and generally a broken conductor. It is altogether desirable, in climates where water freezes in the winter, to run the conductors down on the inner face of the side walls and to make both the strain- ers and conductors of ample capacity to carry off any probable amount of rain or melted snow.

Where the ridges of the saw-teeth run with the length of the building, water can be most conveniently removed from the valleys by conductors placed at intervals of 40 to 60 feet apart in the valleys. Experience in New England seems to show that a 3-inch conductor so placed is amply sufficient to take care of 1000 to 1200 square feet of roof surface, providing the conductor has a free downward run of 12 or 15 feet. A slight pitch of the bottom of the valley toward the conductor opening in the roof is easily effected by fur- ring up the roof of the valley. In a roof recently built from the writer’s design a pitch of 3 inches in 20 feet proved amply sufficient to remove all the water from the bottoms of the valleys. The conductors, after coming through the roof, can be connected into a larger pipe near the roof or be carried down through the room and be disposed of in the basement. The strainer on the roof often fits into a roof thimble made tight with the roof covering, and the thimble runs down into the conductor pipe proper. The connection of the roof thimble with the top of the conductor is frequently a slip joint, made by slipping the thimble some inches down into the conductor, and when the pipe connecting the conductors is near the ceiling, and only slightly pitched, there is danger in very heavy rains of its filling, and of the water backing up and overflowing between the roof thimble and the top of the conductor, unless the connecting pipe is made of very ample proportions. I think it is better to carry the conductors down to and through the floor and gain the effect of the head in the vertical pipe to rapidly discharge the water. The conductors themselves should be of stout construction, where they come down through the room, and ordinary wrought-iron pipe has been found a satisfactory material. Cast-iron soil pipe is liable to be broken, and the sheet-metal conductors of commerce are sure to be bent and dented in factory service. When columns are of iron pipe, or of hollow cast iron, they can be readily utilized for roof conductors; and where the columns are not used for conductors, the conductors can be run in line with the columns without wasting valuable floor space. The writer’s feeling is that it would generally be better to make the plane of the roof level, even when the saw-teeth run across the building. This brings the girders carrying the saw-teeth all on a level and the roof is of uniform height under the girders, which in some measure simplifies the installation of machinery and shafting. Where there is no overhead shafting, a difference of a few feet in the height of the roof at different points may make no difference in the value of the room as working space, and it is cheaper to drain the roof by a few large conductors at the ends of the valleys at the outside walls than by a system of small conductors at intervals, as described.

**PROPORTIONS OF SAW-TEETH**

The proper proportioning of the saw-tooth light is important to obtain the best results without wasting money in their erection. Some saw-tooth roofs have been designed with the span of the saw-tooth very short in relation to the height, thus making the backs of the saw-teeth steep and the valleys sharp and narrow. The result seems to be some loss of light, on account of the obstruction formed by the backs of the saw-teeth themselves, and there is an unnecessary
expense for glass and flashings, as fewer saw-teeth with longer spans, or the same number of saw-teeth with shorter windows, would give all the light needed. The experience of the writer after an examination of the lighting effect in a very considerable number of saw-tooth lighted rooms, designed by different engineers, is that to obtain the best results there should be no intervals between the saw-teeth. A flat place on the roof generally means a shadow, even if slight, or perhaps only a less brightly lighted area, and makes a break in the otherwise almost perfect diffusion of the light. By the same reasoning, the obstruction caused by the necessary space and flashings below the windows and by the supporting girders carrying the saw-tooth frames should be kept at a minimum. With attention paid to these points, a proportion of hight of window to length of span of the saw-tooth, in the ratio of 1 to 3½, or 4, gives all the light desirable in this climate; and if this ratio have been used, I think it is at the expense of greater first cost for glass, and a greater running cost for heating, although special conditions may make the proportions given unsuited to a given case.

DETAILS OF WOOD FRAMING

The three sheets of drawings (Figs. 7, 8 and 9) show types of saw-teeth framed in wood, with some details which the writer believes meet the requirements of this latitude. Very little originality is claimed for these drawings, and which meet conditions better than anything noted, and it is from these that the writer hopes to hear from these that the writer hopes to hear.

From the discussion of these papers we extract the following. Professor Sweet says:

I am led to comment on Mr. Hinds' paper more to correct some mistakes than with an idea of adding much to its value.

In 1889 the weaving-shed roof of the Straight Line Engine Company's Works, in Syracuse, was built, and I supposed at the time and until the appearance of Mr. Hinds' paper that it was the first application in this country of this form of roof to machine-shop use. As a full account of this roof was given on pp. 527 to 535 of the Transactions for 1893, I have only to add that it is on the English plan and with the troubles Mr. Hinds mentions, and these were obviated by making the gutters of cast iron, short enough to go between the trusses, which are only 8-feet centers, and by draining each trough by a separate spout into a continuous conductor running from end to end of the building. As the troughs and conductors are inside the building and are of iron instead of wood, they melt out the snow and ice before it melts on the roof, and hence there is no trouble from freezing ice and snow. The troughs being in sections with a proper joint cover, expansion and contraction have no detrimental effect.

Certain manufacturers of agricultural implements, who are large buyers of iron and steel, have forwarded to President Roosevelt a petition which relates to the tariff on iron and steel. In this petition these manufacturers make certain statements regarding the restriction of the market and their inability to buy under free and competitive conditions, whereupon our contemporary, the Iron Trade Review, informs these manufacturers to the effect that they know little or nothing of what they are talking about, and it concludes its article by saying that "the petition shows either gross ignorance or willful intention to mislead." Very pleasant language to apply to manufacturers who have simply expressed their views as to a public matter affecting their interests!

LEGAL NOTES

BY E. P. BUFFET

CAN LICENSEE SELL PATENTED ARTICLE RESTRICT PRICE?—WHO IS A MANUFACTURER?

An opinion on a commercial question relating to patents, which is said never to have been decided before, has been handed down by the U. S. Circuit Court for the Eastern District of Pennsylvania. Former decisions have established the right of a patentee to impose restrictions upon the future sale or use of a patented article, this being based on his ownership of a monopoly, and his consequent right to declare upon what terms he will admit the public to share in such ownership, or to profit by the use of the article. But if he sells the article without imposing any restriction upon its future sale or use, it passes at once out of the protection of the monopoly, and becomes irrevocably a part of the general property of the community, and may thereafter be bought and sold as freely as any article that has never been patented.

The question here arising was, whether this right in the owner of the patent to lay restrictions passes to his exclusive licensee for the sale of the article, so that the latter, without special authorization, may fix a price at which the property shall be sold to the ultimate purchaser at retail. Can this licensee, for example, prevent a department store from cutting the price on a watch? The court says no, he cannot.

Although the "licensees to sell" in the case at bar have extensive manufacturing works, these particular watches, if the statement of facts accepted by the court be true, were not made by them, but by the owners of the patent. These licensees are stated to have guaranteed the watches and called themselves the manufacturers and may be so considered in about the sense often given to that term by the machinery people. The court, however, looks behind externals and concludes that legally they were not the manufacturers. This might have led to an interesting discussion of the topic, who is a manufacturer?

Before leaving this case it may aid our understanding if I state, and venture a curbstone opinion upon, a few questions bearing on the distinctions of law involved:

1. Is the general right of an owner of a patent to limit the price at which the patented article may be sold enforceable against anyone, no matter how far removed, into whose hands the article may come? Answer—I understand such to be the policy of the law. But something may depend upon whether the ultimate seller has notice of the restriction, as by a label on the article. (See 25 C. C. A., 267; 61 C. C. A. 58.)

2. Would a manufacturer who is using...