makes my head ache to think about it. If the feeling of remorse which shows itself the succeeding day after a centennial celebration becomes intensified with each succeeding century, I hope that the 5th day of jnly 1976, I shall be out of town.

I cannot close this brief oration, fellow-citizens without an earnest appeal to you all to be nobler and better men. Of course if you are women this will not be expected; but we can be good citizens by that time, perhaps, and I earnestly exhort all those within the sound of my voice to be loyal and law-abiding. By all means be industrious, do not wait for me, but form habits of industry at once which will cling to you through life. I am convinced by what I have seen of its effects that it is a good thing. Rise early and go about your duties joyously, and, when the morning meal is prepared and all are gathered about the festive board, come and rap gently, and in a low tone of voice, on the door of my boudoir.—*Bill Nye in Indianapolis Sentinel.*

MACHINERY DESIGNING.—XII.

BY OBERLIN SMITH.

In writing this article upon cams I will, as before intimated, enter into more detail than with some other well-known mechanical constructions, both on account of their intrinsic importance and because they are not usually treated of at any great length in engineering books. Even the exact definition of the word seems to be somewhat obscure, some authorities meaning by the word "cam" the whole wheel from which motion is derived, while others speak of the lugs or projections only. Webster's Dictionary defines the cam as "a projecting part of a wheel or other moving piece, so shaped as to give an alternating or variable motion, of any desired velocity, extent or direction, to another piece pressing against it by sliding or rolling contact." Many of the standard mechanical authorities say nothing about this subject, while others dismiss it in a few words. Cams have been used in some form or other away back almost to prehistoric times, and are perhaps more useful than any other one mechanical device, for the reason that by their use a simple rotary motion can be converted into a reciprocating motion of any desired amplitude, and of any speed, either uniform or variable, in one or both of its directions. They are especially valuable in the case of accurate automatic machinery, where a great many combinations of motion are required in one machine, all of which must have a definite relation to each other in regard to time as well as motion.

The principle of any cam is, of course, nothing more nor less than that of the inclined plane, and its simplest form is shown in Fig. 17, where the sliding block C, moving first left and then right in the line *a a*, as indicated by the arrows *l r*, respectively, elevates and allows to fall its follower F, sliding in the line F *f*, by means of the projection *t*. It is evident that, when C moves left, F will move up as shown by the arrow *u* and that when the descending plane is reached it will move down, as at arrow *d*, providing gravity or the pressure of a spring or some other force is present to depress it. Assuming that the velocity of C is uniform, it is evident that F will rise uniformly, and with the proportions shown, will fall uniformly, but at a faster rate than it rose. If C is made as in Fig. 18, with a concave curved surface substituted for the inclined plane F will obviously rise with an accelerated velocity, while in Fig. 19, where the curve is convex, its speed will decrease. These drawings both provide for a uniform downward movement. In Fig. 20 is shown an inclined plane to give an upward movement and a vertical plane for a downward. This shape is evidently impracticable in actual use, as the descent of the follower would have to be infinitely fast if it really follow the cam. Such a member, however, is used in such well-known constructions as trip hammers, stamping mills, etc, where a rapid descent is desirable rather than the smoothness obtained by a cam motion proper. Such a device as has just been described may fitly be called a sliding cam, and its peculiarity is that, on account of its reciprocating motion, the motion of the follower must be always repeated in reverse order alternately with the primal motion. The sliding cam is not, therefore, practicable in cases where the follower's upward and downward motion are different, and must be repeated in regular succession. Strictly analagous to the sliding cam is the oscillating cam, shown in Fig. 21, where the parts are marked with the same reference letters and where the cam C oscillates upon an axis, *a a*, instead of sliding in a straight line, as in Fig. 17. In effect it is merely the sliding cam bent into the arc of a circle. If it be a convex arc, as here shown, the inclined planes, of course, become convex surfaces, but still give a uniform speed to the follower. It is obvious that a concave oscillating cam, with the inclines made concave to suit, would be just as practicable as the one shown. These oscillating cams possess the same feature, before referred to, of repeating the motions of the follower in reverse order.

In Fig. 22 is shown a rotating cam which, if moving at a uniform angular velocity, will effect the follower during one revolution precisely as in the cases of Figs. 17 and 21, but will give a uniform succession of such movements, without repeating them backward, if allowed to continue revolving. Its rotation is supposed to be to the left, as shown by the arrow at *l*. Of course the surface of C in this case is nothing more nor less than the surface of the straight cam, Fig. 17, bent around into a complete circle.

It is evident that the motions given to F in Figs. 17 and 21 might be produced if C moved in some other direction than a straight line or a circular arc respectively, but such a case would rarely occur in practice. An instance, however, where such a device might easily be applied would be in the case of a pitman, one end of which is moving in a circle and the other in a straight line, but all other points of which are moving in other curves, somewhat analagous to ellipses. It is obvious that a cam surface might be applied to the side of a pitman, either between its cross head and crank, or, indeed, upon the end of it produced beyond the crank, although this is a device that I have never happened to see used.

In general practice, then, we have sliding cams, oscillating cams and rotating cams. An ordinary instance of the former can be seen in almost any steam hammer, where the ram is fitted with an inclined groove to work the steam valve. A still more common use of sliding or oscillating cams is seen in ordinary door locks and latches, in which case, however, the inclined part is oftener upon the follower than upon the cam itself. It will not be necessary to treat further of these devices, as they can be constructed upon precisely the same principles as can rotating cams, and these principles will be explained further on. The last-mentioned device will hereinafter be spoken of simply as a cam, and, following the general practice in our shops and drafting-rooms, I shall speak of the whole wheel, including its various inclines and projections, as simply a "cam," the dictionaries to the contrary, notwithstanding. Where necessary, I shall speak of any definite projection, like *t*, as a "tooth" or a "cam-tooth," as the case may be. It is very difficult, however, as in many other departments of mechanical nomenclature, to make such definitions exact. One would hardly know what part to call a tooth in such forms as are shown in Figs. 25 or 26, where the projection extends all the way around the cam. Perhaps as good a pratical definition as any for the word in question would be "a rotating wheel, carrying two or more inclined planes which actuate a reciprocating follower by sliding or rolling contact." If it be objected that the inclines are not necessarily planes, we may answer that any curved surfaces, such as are shown in Figs. 17, 18 and 19, may be considered as being made up of an infinite number of short inclines, each at a different angle to the line of motion of C.

We will next consider other directions of motion for the follower in relation to a cam's axis than that shown in Fig. 22, where F is supposed to slide in an axial plane, but a radial direction, and where the primal form of the cam surface is cylindrical or made up of elements parallel to those of a cylinder. In Fig. 23 is shown a cam, C, revolving uniformly upon an axis, *a*, which will give precisely the same motion to F as will Fig. 22, and F's line of motion may still be in an axial plane, but parallel to the axis *a*, instead of perpendicular to it, as in Fig. 22. In Fig. 24 is shown a cam tooth, *t*, mounted upon a conical surface instead of upon the side or end of a cylinder, as in the two previous figures. The motion of F will be as before, and may still be in the same plane, but its direction will be at an angle some other than a right angle to the axis. Although this is shown as an external conical surface, it is evident that an internal surface might just as well be used, as also might an internal cylindrical surface in place of Fig. 22. The use of conical cams is, however not very frequent. There are, however, cases where it is convenient to place them upon a shaft which must, for some good reason, run in a direction inclined to the follower's line of motion. In general, the form shown in Fig. 22 may be called an "edge-cam," and that in Fig. 23 a "side-cam," and it may here be said that all the constructions shown in this article may be classed in general