# CHAPTER 12

# Machine and Inverse Escapements

## MACHINE AND INVERSE ESCAPEMENTS IN GENERAL

In this chapter two more types of mechanisms will be considered—machine escapements and inverse escapements. Neither of these is as popular with machine designers as are ratchets, cams, or Genevas, but both deserve more attention than they get, since they offer the designer significant advantages in many design situations. Both machine and inverse escapements look very much like clock escapements, but neither is designed to run synchronously and both are designed to handle considerably larger loads than the typical clock escapement. Despite the geometrical similarities between these two types of mechanism, they will be discussed separately (machine escapements first) because they differ quite a bit in their operation.

## MACHINE ESCAPEMENTS

### Description of Machine Escapements

A typical machine escapement is shown in Fig. 12–1. As can be seen from the drawing it looks like a clock escapement except that the scape lever is controlled by the rotation of a snail cam rather than by a pendulum. The scape lever, of course, could also be controlled by a solenoid rather than by an input cam. This would place the length of the dwell period under the control of the operator. In either case, one of the two teeth (pallets) of the scape lever is always in a position to interfere with the motion of the scape wheel which, therefore, can never run away.

As in a clock escapement, the scape wheel in Fig. 12–1 is continuously urged to rotate by the machine to which it is fastened. A spring or weight could be used, as in a clock or watch, but a slip clutch or stallable motor is more commonly used in machine design. Sometimes, both a spring and slip clutch are used, the clutch being used to limit the torque that keeps the spring wound. Spring loaded escapements are usually called "load-and-fire" escapements. Examples of these will be seen later on.

The machine escapement is similar in some ways to certain types of limited motion clutches. In the next chapter a one-turn ratchet clutch will be seen, for example, that might well be mistaken for a machine escapement. The difference is that an escapement controls or releases energy in some other mechanism; a clutch transmits energy from drive to load.

Figure 12–2 shows another machine escapement. It differs from Fig. 12–1 in that the scape lever has only a single pallet. This mechanism will function correctly only if the scape lever moves rapidly enough to catch each tooth of the scape wheel after every motion of the wheel. As mentioned in Fig. 12–1 one of the two pallets of that scape lever is always in a position to interfere with the motion of the scape wheel. The mechanism of Fig. 12–2, relying as it does on a race between the scape lever and the scape wheel, is a more risky mechanism; but, never-

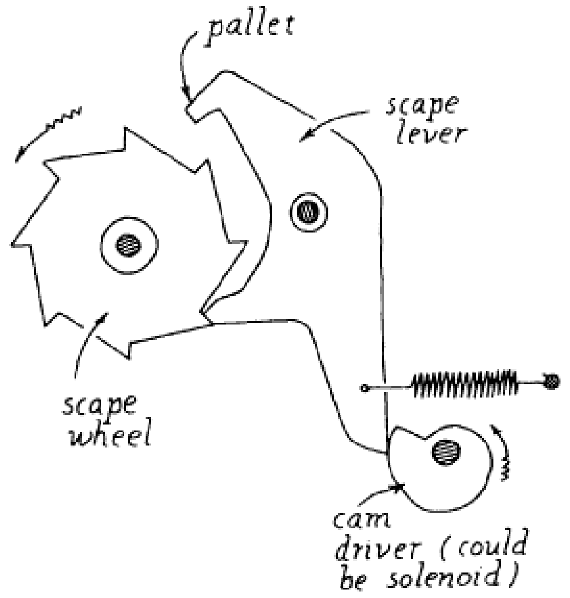



Fig. 12–1. Typical machine escapement.

theless, the single pallet escapement can be made to function correctly with proper design.

One way to help the single-pallet scape lever function correctly is to spring load it in the manner shown in Fig. 12–3A. Every time the pallet escapes a tooth on the wheel the lever, provided with a slot, immediately jumps ahead and downward (Fig. 12–3B). This trick gives the lever more time to re-engage the wheel (or catch the next tooth). The spring also acts to cushion the impacts that occur when the wheel is stopped by the lever.

## Advantages and Disadvantages of Machine Escapements

One favorable attribute of the machine escapement is the fact that it has a large mechanical ad-

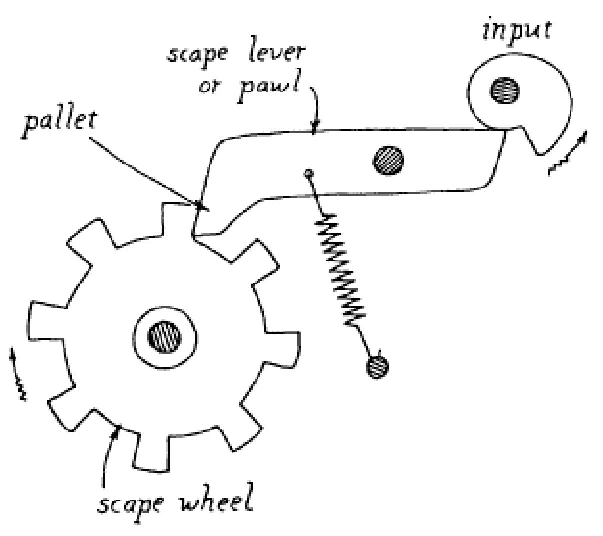



Fig. 12–2. Machine escapement with single-pallet scape lever.

vantage. A small amount of control energy from a low torque rotating shaft or a lightweight solenoid can control (release) a large amount of energy or torque in the scape wheel and remainder of the machine. The only energy which has to be supplied to the control system is that required to extract the scape lever from the scape wheel. The ratio between this energy or torque and that which is controlled, is the same as the ratio between the normal force on the lever and the frictional resistance to its motion. Since the friction force can usually be kept at 10 or 20 percent of the normal force, one unit of energy can easily control ten. With special attention paid to the shape and surface treatment of the scape lever and wheel teeth, with proper balancing of scape lever, etc., the control to output torque ratio can be even greater than this.

This mechanical advantage leads to an additional advantage. The machine escapement can be operated

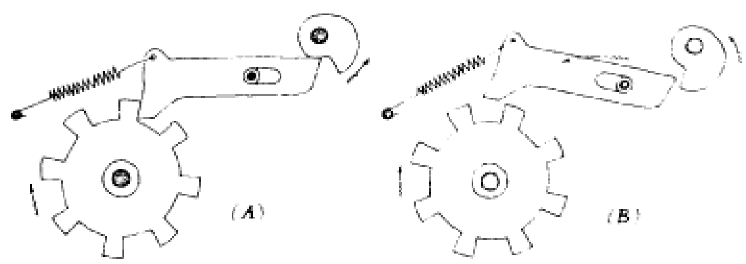



Fig. 12–3. Single-pallet machine escapement. (A) Engaged. (B) Disengaged.

at very high speeds because we do not have to wait for large drive torques to be developed by the system. Such torques are always present (produced by stalled motors, wound springs, slip clutches, etc.) urging the scape wheel forward. The escapement need only produce a small control torque which releases the drive torque. Solenoids, motors, or springs which drive the scape lever, therefore, can be small and the inertia of the escapement parts can be very small. All of this can result in very high speeds (with proper design of the drive circuits, etc.).

A different advantage can be obtained with the "load-and-fire" type of machine escapement. Here, a low-power motor can be used (with suitable gearing) to wind a large spring slowly. A very small control solenoid or equivalent is then used to actuate an escapement to release the energy in this spring. The system produces large output torques with low input energy and torque requirements. Of course, cycle rates have to be slow enough to allow the low-energy motor to wind up the high-torque spring, but this is not a serious disadvantage in many cases.

Another advantage is the machine escapement; it is a very simple device, even simpler than a ratchet. There is no need for such things as a no-back pawl, non-overthrow pawl, pawl springs, etc. Simplicity, in turn, leads generally to lower costs and to improved reliability. Finally, the machine escapement keeps the load under control quite reliably, although there is a period during which the load is free-wheeling between stops. If the escapement is designed properly, the load (scape wheel) cannot get very far before it is stopped (motion control).

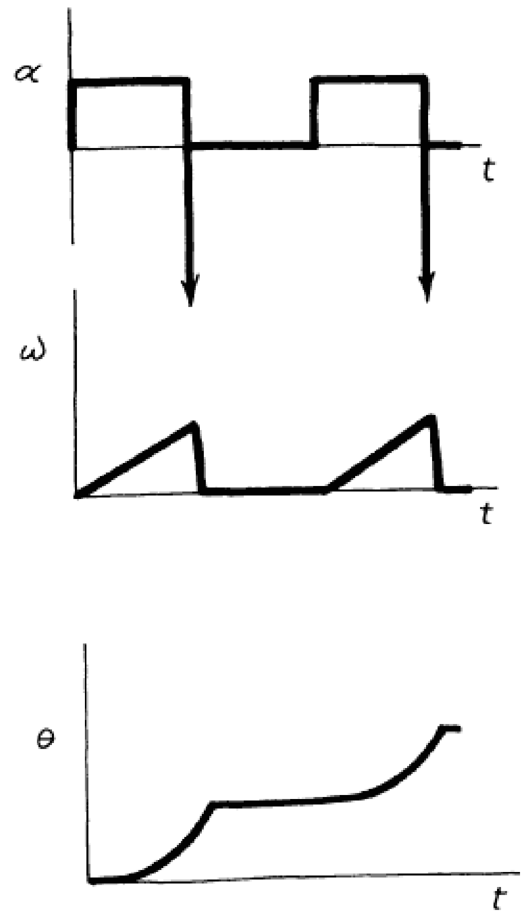



Fig. 12-4. Motion curves of a typical machine escapement. Notice the similarity to the curves of a clock escapement in Fig. 11-5.

There are disadvantages to machine escapements, however. This is an impact mechanism, probably producing more severe impacts than a ratchet, since full drive torque is usually applied to the scape wheel at all times. This means that machine escapements can only be used in relatively light-duty applications and can only take short steps (perhaps one revolution, as a maximum) to reduce impacts. Motion times are always short, therefore, but the dwell period can be placed under the control of the operator, if this is desirable.

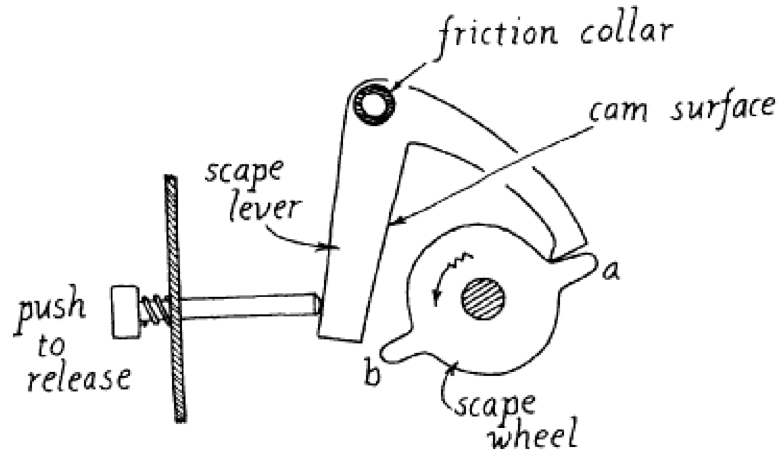



Fig. 12-5. Manually operated escapement in a towel dispenser.

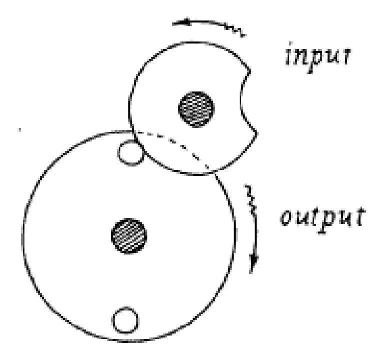
### Motion Curves—Machine Escapements

Motion curves for the scape wheel of a typical machine escapement are shown in Fig. 12-4. These are identical to the motion curves for a clock escapement and are characterized by a constant torque period (following release of the scape wheel) followed by a severe impact as the wheel is stopped when it strikes the next pallet of the scape lever.

### Examples of Machine Escapements

In this manually operated escapement, from a towel dispenser (Fig. 12-5), the operator pushes the control button which moves the scape lever counterclockwise until it strikes the wheel. He is now free to pull a towel from the dispenser. This act rotates the scape wheel, and tooth *a* of the scape wheel acts on the cam surface of the scape lever to move the scape lever back into the position shown in the illustration. This brings the right-hand pallet of the scape lever into position to interfere with tooth *b* on the scape wheel, and thus prevent the operator from getting more than one towel.

Figure 12-6 illustrates a very simple machine




*Drawing courtesy of MACHINE DESIGN Magazine; Dec. 23, 1965; p. 121 ff*

Fig. 12-6. Simple machine escapement with a rotating input.