CHAPTER 9

Geneva Mechanisms

INTRODUCTION

The Geneva is one of the earliest of all intermittent motion mechanisms and when input is in the form of continuous rotation, it is probably still the most commonly used. Genevas are available on an off-the-shelf basis from several manufacturers, in a variety of sizes. They are cheaper than cams or star wheels and have adequate-to-good performance characteristics, depending on load factors and other design requirements. Figure 9–1 shows a typical, four-slot external Geneva.

Advantages of Genevas

Genevas may be the simplest and least expensive of all intermittent motion mechanisms. As mentioned before, they come in a wide variety of sizes, ranging from those used in instruments, to those used in machine tools to index spindle carriers weighing several tons. They have good motion-curve characteristics compared to ratchets, but exhibit more "jerk," or instantaneous change in acceleration, than do better cam systems (the Geneva, you will remember, is a special type of cam system).

The Geneva maintains good control of its load at all times, since it is provided with locking ring surfaces, as shown in Fig. 9–1, to hold the output during dwell periods. In addition, if properly sized to the load, the Geneva generally exhibits very long life. One machine tool manufacturer told me that their Genevas will last 20 years, indexing once every few seconds, on a three-shift basis, driving a spindle carrier weighing one ton. This particular Geneva was about 18 inches in diameter.

Disadvantages of Genevas

The Geneva is not a versatile mechanism. It can be used to produce no less than three, and usually no more than 18 dwells per revolution of the output shaft. Furthermore, once the number of dwells has been selected, the designer is well locked into a given set of motion curves. The ratio of dwell period to motion period is also established once the number of dwells per revolution has been selected. Also, all Geneva acceleration curves start and end with finite acceleration and deceleration. This means they produce jerk.

Types of Genevas

There are three types of Genevas: (1) external, which is the most popular, and which is represented by the device shown in Fig. 9–1; (2) internal, which is also very common and is illustrated by Fig. 9–2; and (3) spherical, Fig. 9–3, which is extremely rare. We will take a closer look at some external and internal Genevas later on, but will not spend more time on the spherical type.

Genevas are also combined with a wide variety of other mechanisms, such as four-bar linkages; clutch-brake combinations; noncircular gears; etc., to modify the motion curves and dwell–motion ratios obtained from a pure Geneva. We will see several different examples of these later.

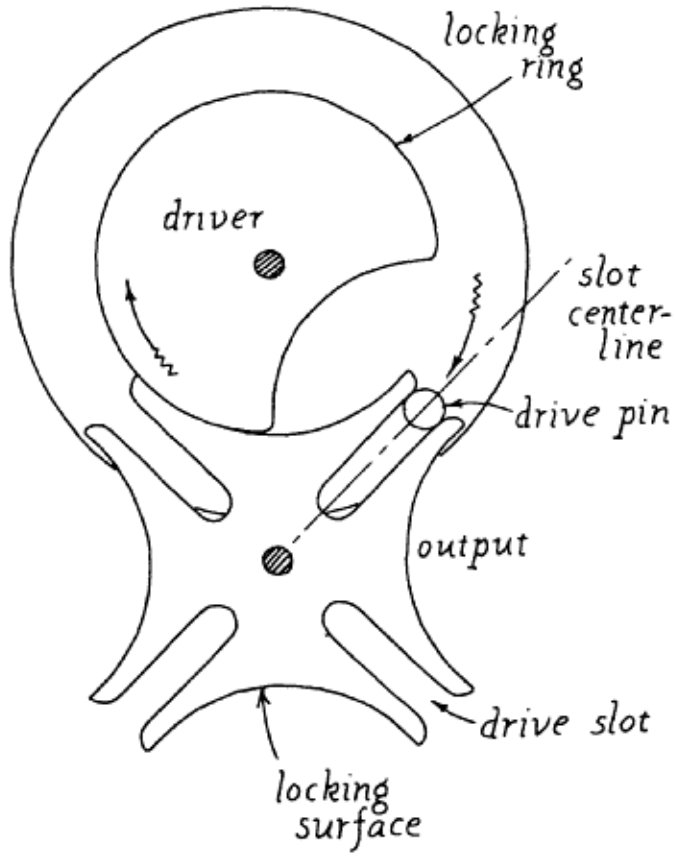

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Fig. 9–1. Four-slot external Geneva.

Motion Curves

The motion curves for several external Genevas are shown in Fig. 9–4; and for internal Genevas, in Fig. 9–5. As can be seen, the two curve sets differ quite drastically in shape. Figure 9–6 shows the motion curves for four-slot internal and external Genevas superimposed for comparison.

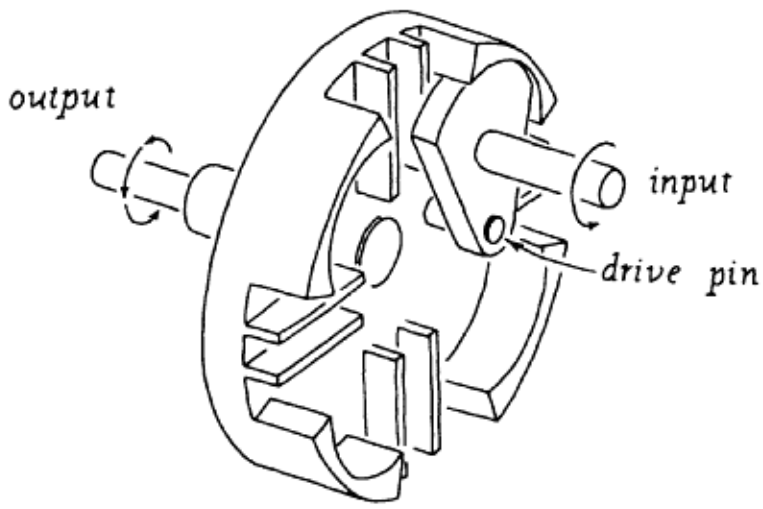

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Fig. 9–2. Four-slot internal Geneva.

A few general comments can be made about these motion curves.

1. For an external Geneva, the dwell period always exceeds the motion period.
2. For an external Geneva, the dwell period always lasts longer than the time required for 180 degrees of motion of the input driver.
3. For an internal Geneva, the motion period always exceeds the dwell period.
4. For an internal Geneva, the dwell period is always shorter than the time required for 180 degrees of input.

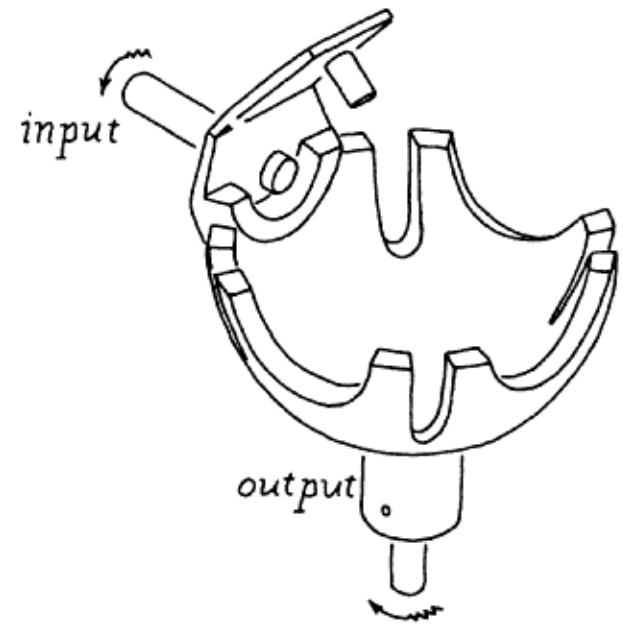

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Fig. 9–3. Four-slot spherical Geneva.

5. For a spherical geneva, the dwell period equals the motion period, and equals the time required for exactly 180 degrees of input.
6. The magnitude of peak acceleration and deceleration, velocity, etc., obtained with a Geneva, is a function of the number of slots or dwells. This is true of all types.

As the ratio between the diameter of the wheel and the diameter of the driver gets larger (more slots or dwell periods per revolution of the output), maximum accelerations and velocities decrease (for a given driver speed). This makes sense because the indexing angle of the output decreases as the number of slots increases.

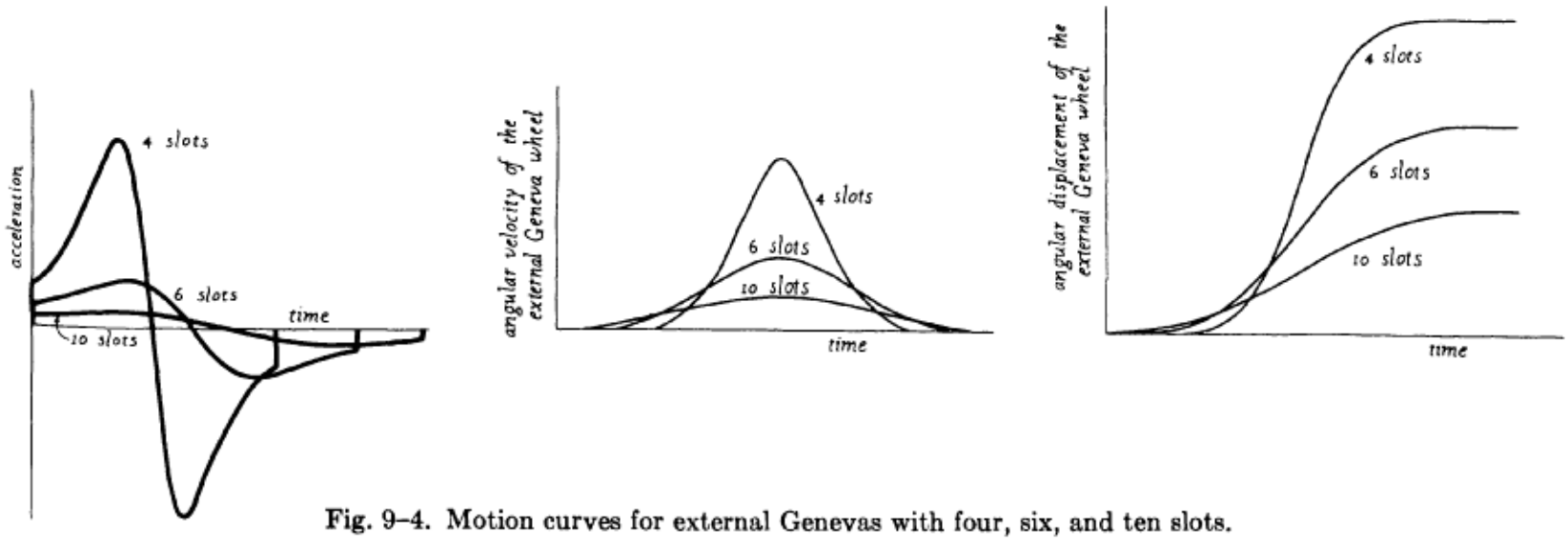

Fig. 9–4. Motion curves for external Genevas with four, six, and ten slots.

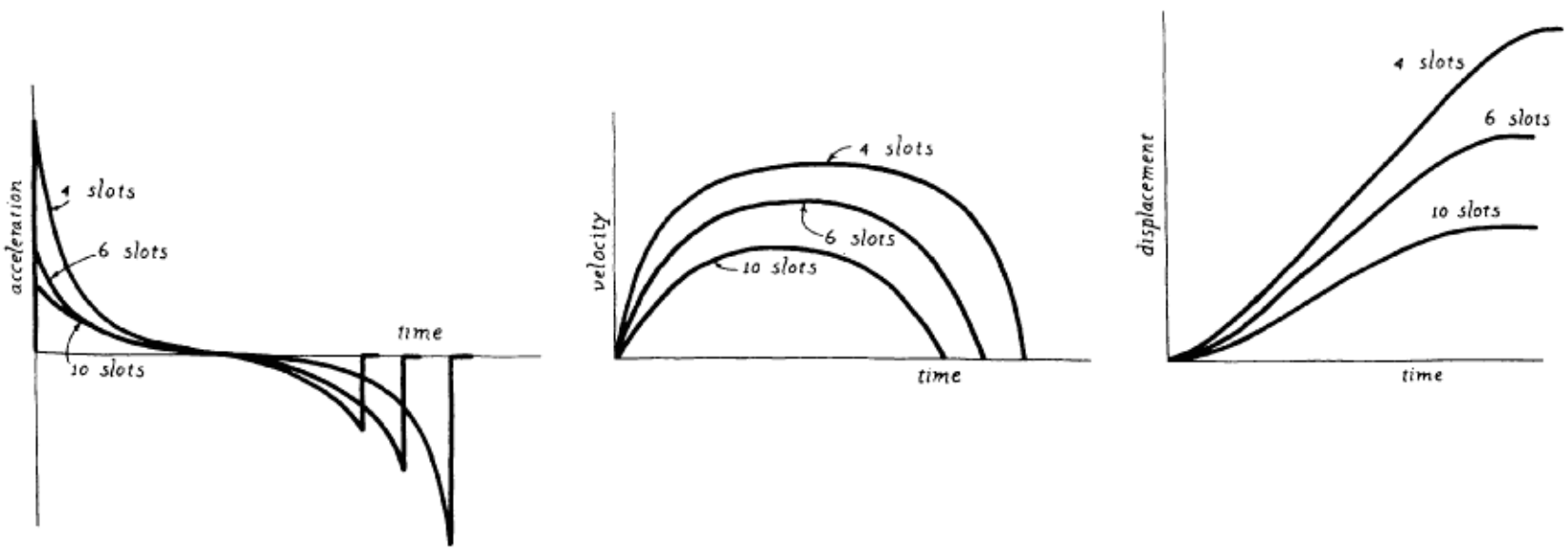

Fig. 9–5. Motion curves for internal Genevas with four, six, and ten slots.

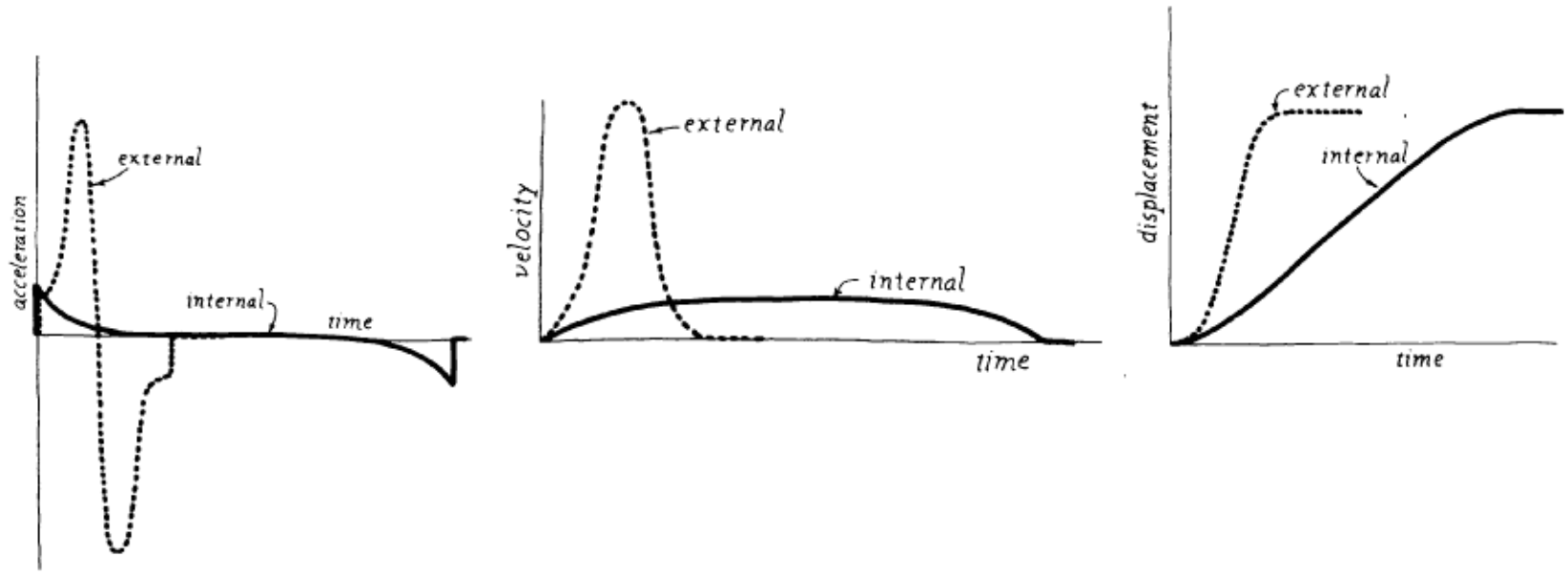

Fig. 9–6. Comparison of the motion curves of internal and external Genevas with four slots.

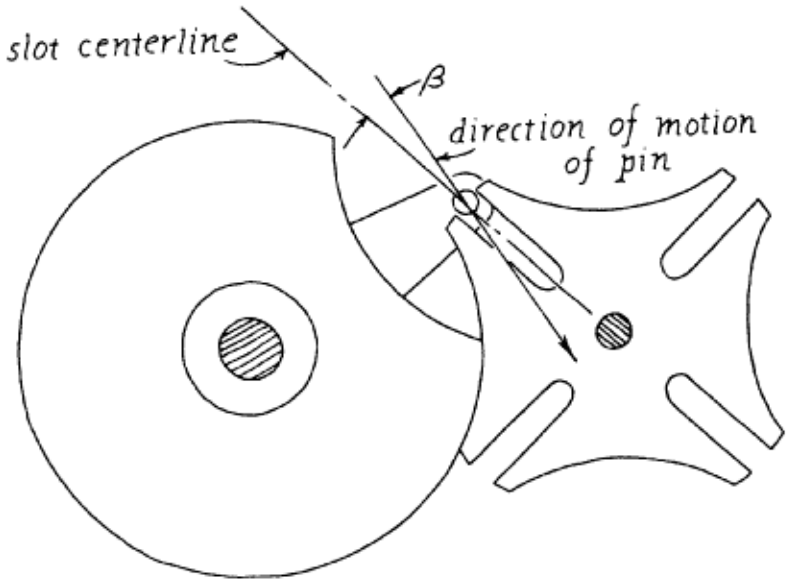

Fig. 9–7. The drive pin of the Geneva should enter the slots in the driven wheel along an arc that is tangent to the centerline of the slot, rather than along a line which deviates from the slot centerline by some angle β, as shown here.

Miscellaneous Comments

In a well-designed Geneva the drive pin will enter the slots of the output wheel along an arc that is tangent to the centerline of the slot, as shown in Fig. 9–1. If the direction of motion of the pin deviates from the slot centerline by an angle β, shown in Fig. 9–7, impact can result. This will either be a positive or negative impact (that is, it will produce either a positive or a negative torque on the driver) depending upon whether the slot is at some angle above the tangent line of the pin's motion or at some angle below it. (Figure 9–7 shows a situation where the tangent line is below the pin's motion line.)

Figure 9–8 shows the displacement curves that result from three situations: the deviation (angle β) is ± 5 degrees or 0 degrees (tangent). There does not seem to be much difference between these three curves, each of which represents only the first few degrees of motion of the output member rather than the complete displacement curve, as per Fig. 9–4. The velocity curves for these three situations, also shown in Fig. 9–8, do not appear to have changed much either.

If we now plot the acceleration curves, however, we will find that we have introduced impact when the slot's centerline was above or below the line tangent to the pin's motion. This is because the angular velocity in each case starts at a finite positive or negative value; and instantaneous change in velocity means an infinite acceleration which, in turn, means impact. In practice, of course, a small initial velocity would mean a relatively small impact (even though theory says any instantaneous change means an infinite acceleration) and would cause no trouble. If the machine is operated at high speeds, however, or under heavy loads, or with elastic connections between parts, even a small, sudden change in velocity can cause severe impact, stress, vibration, lost motion, jamming, etc. Figure 9–9 shows the acceleration curves for the three situations.

As discussed in Chapter 5, a high-speed or heavily loaded Geneva can also get into difficulty if the pin is not a good running fit in the slots in the output

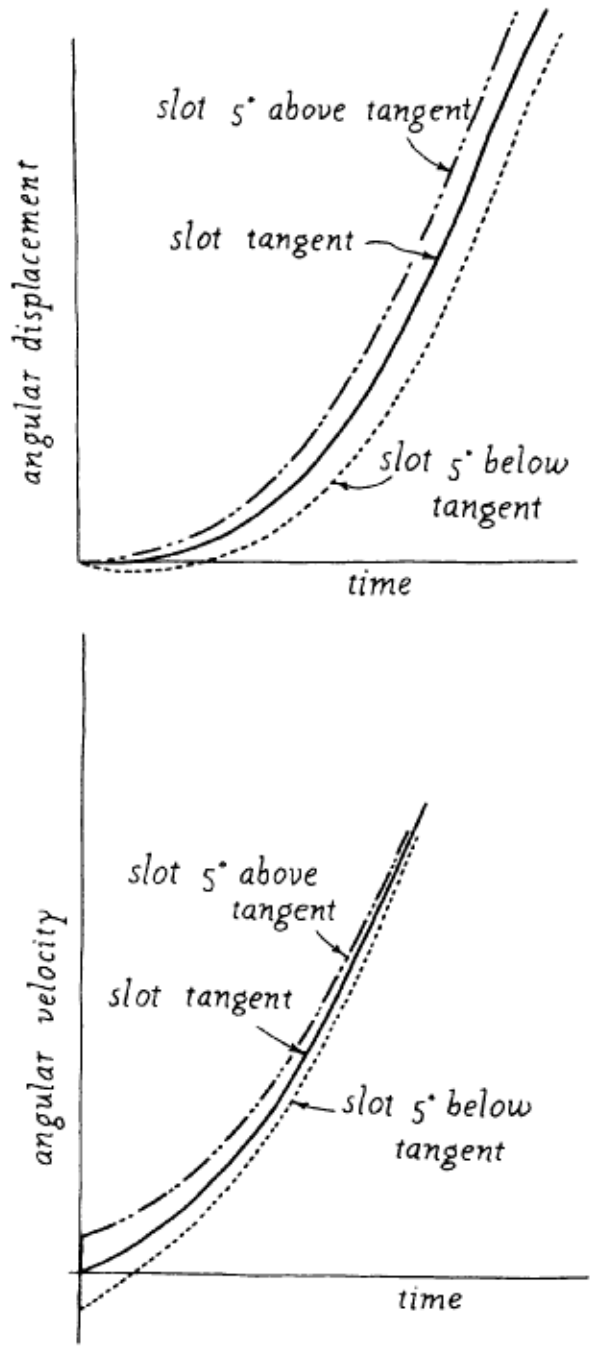

Fig. 9–8. Displacement and velocity curves of an external Geneva when the direction of motion of the drive pin is tangent to the slot; when the slot is 5 degrees above the tangent line; and when it is 5 degrees below it (the latter situation is shown in Fig. 9–7).

wheel. Elasticity in the system may allow the pin to chatter from one side of the slot to the other as it drives the wheel, producing a series of impacts which can cause all sorts of trouble. (See Figs. 5–9 and 5–10 for the resultant motion curves.)

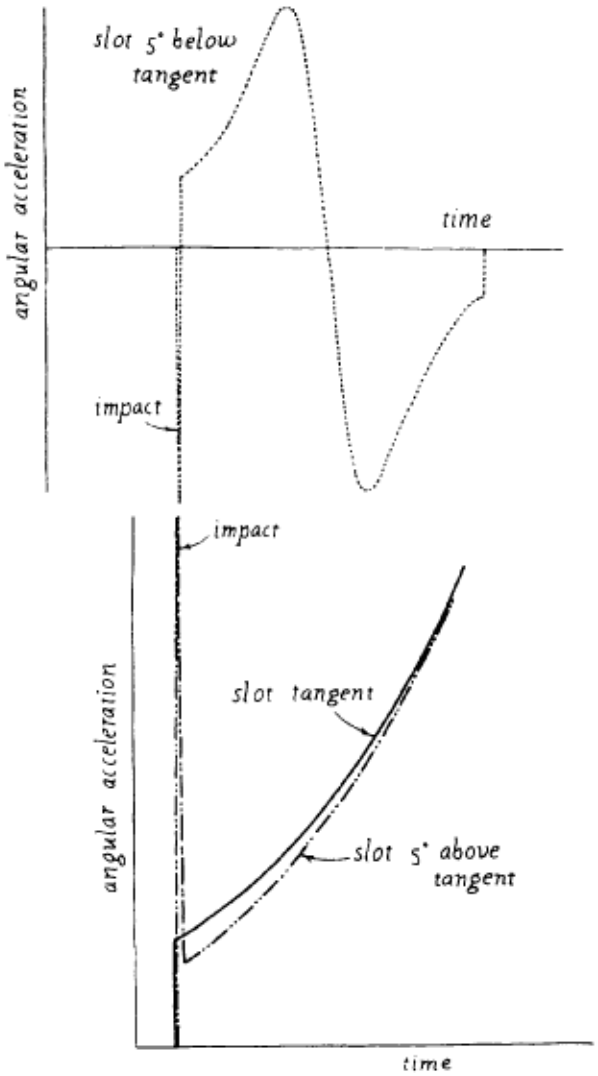

Fig. 9–9. Acceleration curves for tangent and ±5 degrees misaligned slots.

Four sketches of external Genevas with five, six, eight, and ten slots, respectively, are shown in Fig. 9–10. Notice how the ratio between the diameter of the driver and the diameter of the wheel decreases

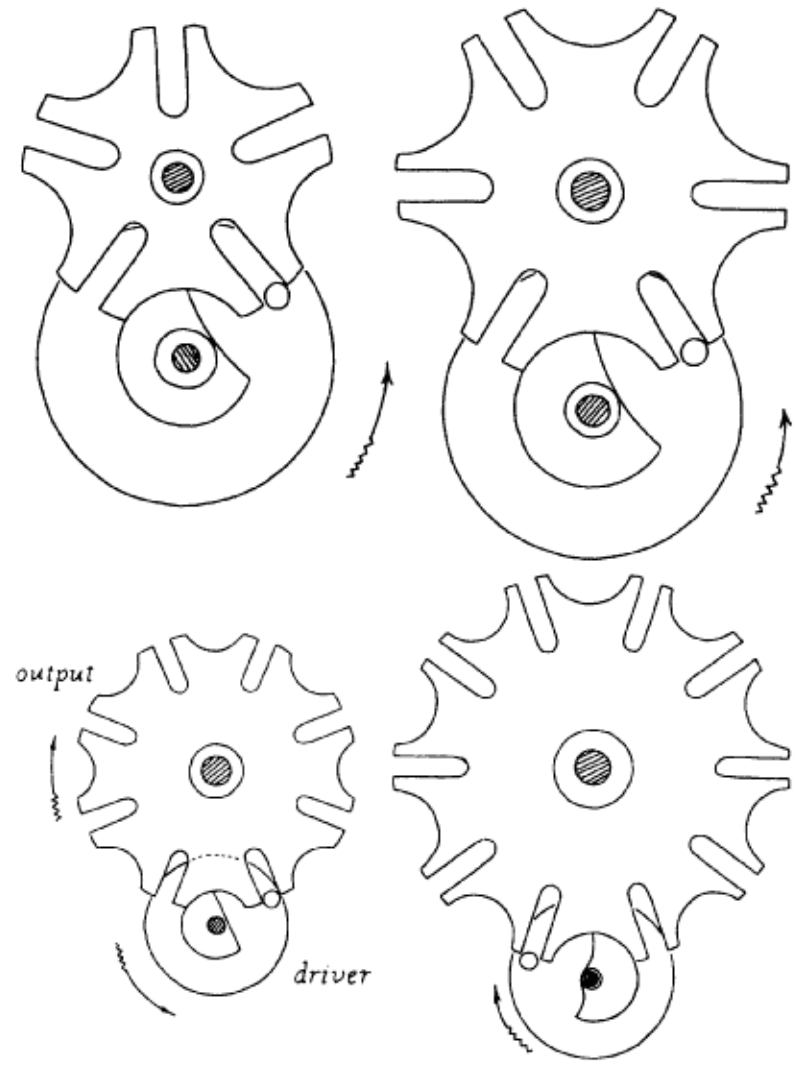

Fig. 9–10. External Genevas with five, six, eight, and ten slots, respectively.

as the number of slots increases. Notice also, that the indexing angle decreases.

Three internal Genevas with four, eight, and twelve slots are illustrated in Fig. 9–11. Again, notice how the ratio of driver diameter to output wheel-diameter decreases as the number of slots increases. Notice too, that the driver must be mounted on a cantilevered shaft in each case, whereas the external Geneva of the previous illustration could have both input and output members mounted on through

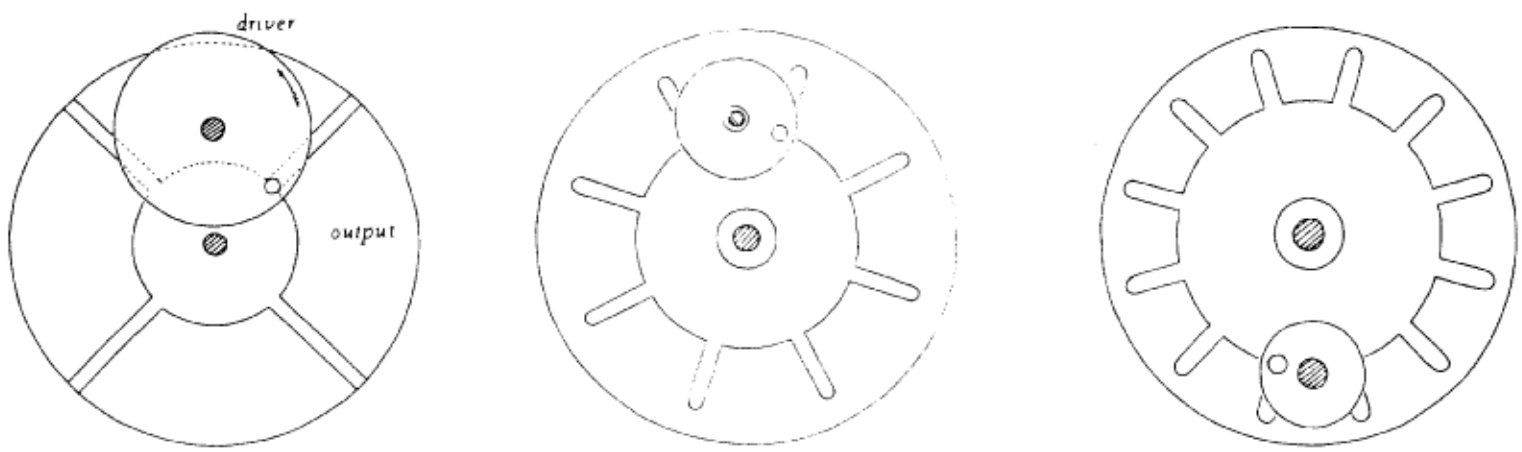

Fig. 9–11. Internal Genevas with four, eight, and twelve slots.