THE PYROTECHNIC WHISTLE AND ITS APPLICATIONS

Selçuk Öztap

1. Introduction

The pyrotechnic whistle is one of the curiosities of special pyrotechnic compositions. The following examples of several of the author's inventions are being published to stimulate the discovery of new principles, and to expand practice to new applications while improving the old. This work presents many of the author's studies hitherto known only to a few.

2. Fundamental characteristics of the whistle

Whistling compositions have two important characteristics upon combustion: a whistling sound and a simultaneous thrust force. Light from the whistle flame is weak and of limited usefulness. Usually powdered composition is charged into a tube closed at one end and consolidated by pressing, leaving the opposite end open. The frequency of the sound varies with the void space above the pressed composition and the shape of the burning surface. Also, a small quantity of granular composition (0.03-0.50 gram) placed in a closed bottom of a tube without pressing produces a short, loud whistling sound. The author calls this "thunder whistle." This effect is obtained even with 1 - 3 grams of granular composition unconfined in the open air (Öztap 1965).

Thrust comes from vibrational burning of the composition. Here, the ordinary rocket engine nozzle is not necessary to produce thrust. The principle of thrust generation may be the same as that of the pulse jet engine. The strength of the thrust depends upon the type of composition and burning area.

3. Whistling composition

In practice there are several types of whistle composition. The author concentrated on a composition using potassium chlorate, sodium salicylate, a lubricant, and ferric oxide (Fe_2O_3; iron (III) oxide) (Öztap 1968). The cheaper potassium chlorate is used instead of perchlorate. Sodium salicylate is used because it gives more thrust than sodium benzoate. The author uses paraffin oil, castor oil or vaseline as the lubricant. The lubricant decreases the sensitivity of the composition as is the case for chlorate explosives (cheddite). It also retards moisture absorption by the composition containing sodium salicylate, and inhibits flying dust from the composition during the manufacturing process. Ferric oxide is used as a catalyst for the decomposition of potassium chlorate. Other heavy metal oxides, MnO_2, PbO_2, CuO, and Pb_3O_4, can be used as catalysts in substitution.

Three strengths of compositions are given in Table 1, and representative formulations are shown in Table 2.

Table 1.

Classification of whistling compositions by thrust

Class	Thrust	Sodium salicylate	Lubricant (vaseline, etc.)
1	Normal	8 - 12%	8 - 12%
2	Larger	12 - 16	6 - 8
3	Largest	16 - 20	3 - 6

Table 2. Examples of whistling compositions (I)

Class	1.	2.	3.
Potassium chlorate (170 - 200 mesh)	79.80%	80%	73%
Sodium salicylate (170 - 200 mesh)	9.80	12	20
Lubricant	P: 10.20	C: 6	V: 6
Ferric oxide Fe_2O_3 (fine powder)	0.20	2	1

In Table 2, P is paraffin oil, C is castor oil and V is vaseline. The mesh size of the component materials is important, especially for potassium chlorate and sodium salicylate: the smaller the particles, the greater the thrust and the better the sound quality. The author uses ballmilled 170 - 200 mesh composition, which doubles the effect of the commercial 120 mesh material. In this way, one can decrease the percentage of the salicylate fuel below that in ordinary whistles. To regulate thrust, the ratio of potassium chlorate to sodium salicylate is changed; for example, as 73/20, 74/19, 75/18, 76/17, 77/16, which progressively lessens the thrust and produces a series of different frequencies. Other types of composition are also listed in Table 3.

Table 3. Examples of whistling compositions (II)

Class	3-2	3-3
Potassium perchlorate (170 - 200 mesh)	—	75.2%
Potassium chlorate (170 - 200 mesh)	76%	—
Sodium benzoate (170 - 200 mesh)	20	—
Sodium salicylate (170 - 200 mesh)	—	19.8
Vaseline	3	—
Paraffin oil	—	3.0
Ferric oxide Fe_2O_3 (fine powder)	1	2.0

Ordinary powdered composition is prepared as follows. Castor oil is mixed with an equal quantity of ethyl alcohol (ethanol, 96.6%). This mixture is combined with the sodium salicylate and ferric oxide. Potassium chlorate is then added to the mixture. Paraffin oil or vaseline is mixed with benzene and toluene. This is mixed with the salicylate and ferric oxide in a mixer to emulsify it. Finally, potassium chlorate is added to the mixture, which is kneaded and dried.

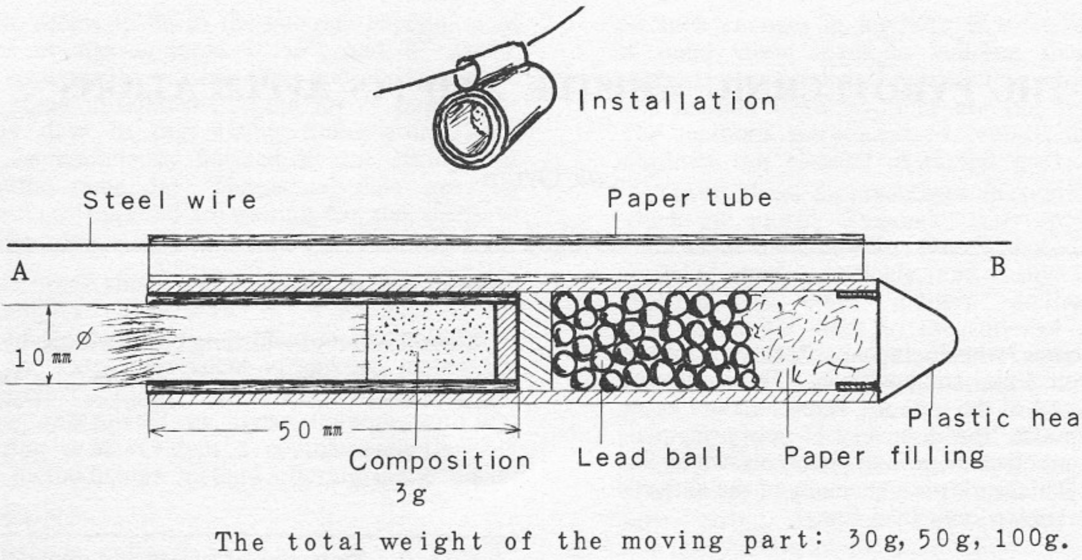

Figure 1. "Cable car" type device for thrust estimation.

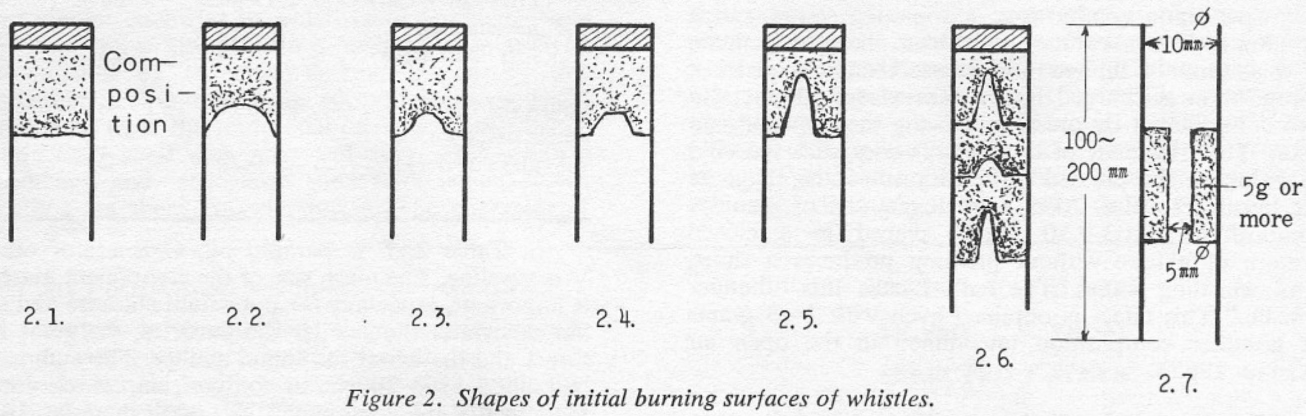

Figure 2. Shapes of initial burning surfaces of whistles.

Granular composition for use as a thunder whistle is prepared with a water soluble binder in place of the lubricant to prevent dusting during handling. Three grams of dextrin or gum arabic are dissolved in 22ml of cold, 40% aqueous ethanol. One gram of ferric oxide and 75 grams of very fine potassium chlorate are well mixed, and 21 grams of very fine sodium salicylate are then added to it. Finally the binder solution is added and mixed well. The composition is placed in a 1mm mesh nylon sieve and pressed through by hand. The wet grains come through the underside and are dried naturally on linoleum at 20 - 30°C. The ethanol solution must be cold to avoid the growth of sodium salicylate crystals. This composition is almost the same as 3 - 3 except for the binder.

4. Fundamental manufacturing operations, designs and thrust estimation

The following procedure is typical for making an ordinary whistle. A quantity of the powdered whistle composition is charged into a tube having 10mm inside diameter, 15mm outside diameter, and 50mm length, pressed at 1000 kg/cm². The tube is made of kraft paper or aluminum and one end is closed with clay. The tube is usually inserted into a metal mold before pressing. The thrust is estimated roughly but conveniently with a "cable car" type device (see Fig. 1) in calm weather.

The shape of the initial burning surface of the pressed composition has a large influence upon the thrust and whistling sound. Figure 2 shows various shapes of the surface which give different frequencies and thrusts. Figure 2.1 is the ordinary flat shape, producing uniform sound and thrust (the frequency changes somewhat with the burning time). The shapes from Figures 2.2 to 2.5 initially give a loud, curious sound with the greatest thrust.

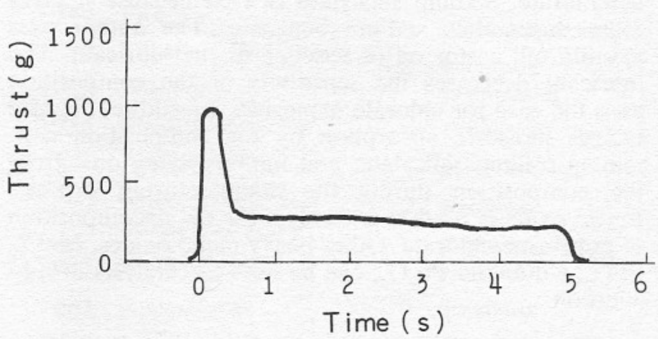

Figure 3. Thrust-time curve for a hollowed burning surface.

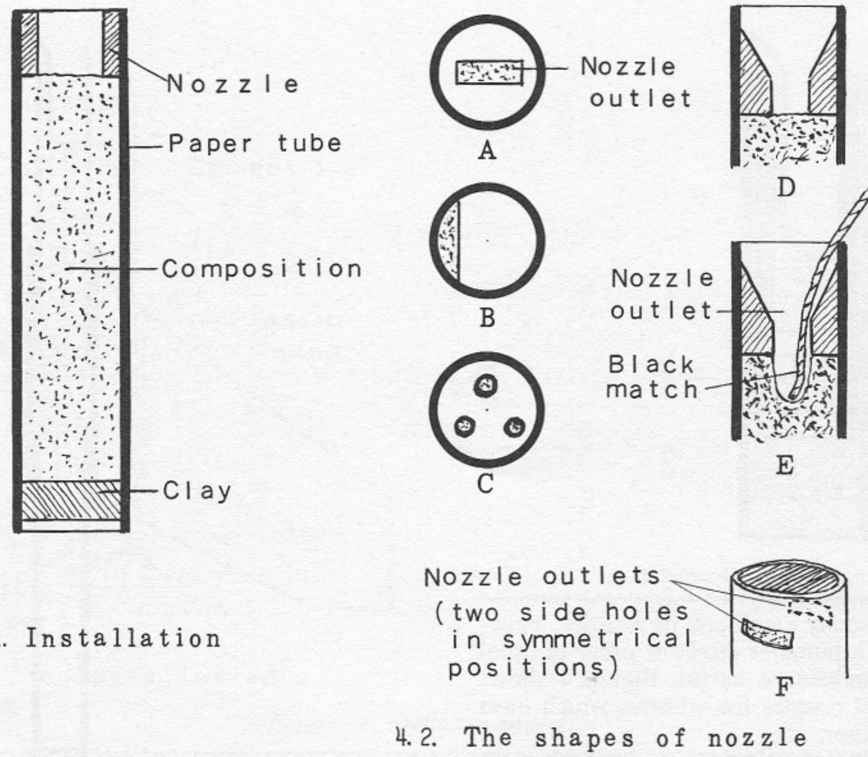

Figure 4. A nozzle incorporated in a whistle.

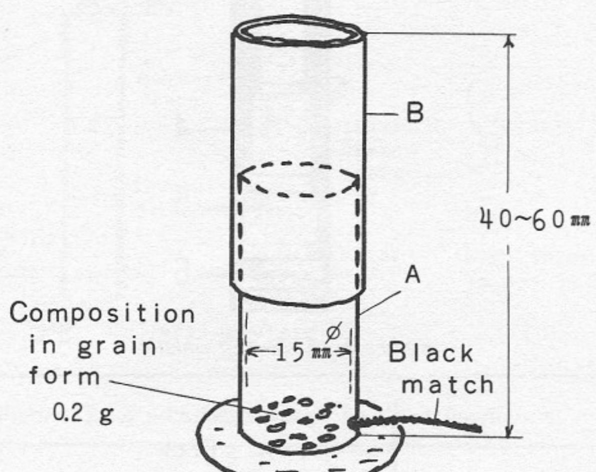

Figure 5. Thunder whistle.

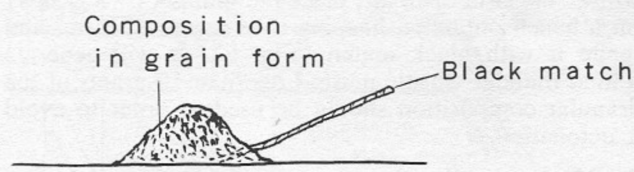

Figure 6. Thunder whistle test.

The conic hollow at the initial burning surface (see Fig. 2.5) was devised by the author in 1965 (Öztap 1976a). When five grams of pressed composition with a conic hollow 20mm in length is ignited, the initial thrust is 1000 grams, decreasing to 200 grams, measured by a spring balance as shown in Figure 3. Figure 2.6 shows a three-step effect caused by three different shapes. Figure 2.7 shows a cylindrically shaped composition which could be used for an alarm whistle or warning horn.

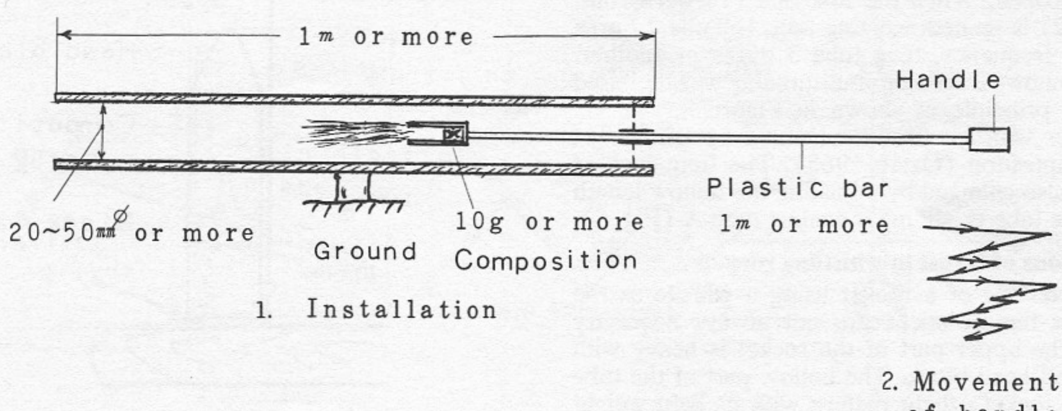

Figure 7. A pyrotechnic trombone.

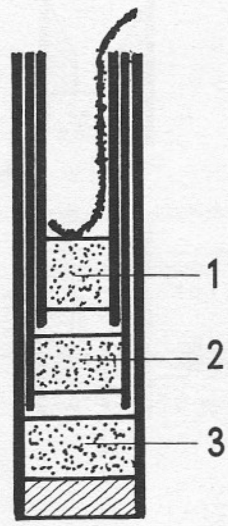

Figure 8. A three-step whistle.

Nozzles are not usually employed in whistles. However, when we desire a hummer effect or other unusual noise, a nozzle may indeed be useful. Figure 4 shows various types of useful nozzles for whistles which have been tried by the author.

Granular composition is placed only in the bottom of a tube to obtain a thunder whistle effect. It is not pressed (see Fig. 5) (Öztap 1976b). To test the thunder whistle effect in open air, place the grains (1 - 3 grams) on a bench outdoors, heaping it in a conical form, and ignite it with black match (Fig. 6). It will generate a loud thunder whistle noise. Less than 10 grams of the granular composition should be used in order to avoid a detonation.

5. Musical applications

Whistle frequency is changed by varying the hollow length of the tube. A representative example explaining this principle is shown in Figure 7. Ten grams of whistle composition is placed in a long hollow tube. The whistle is attached to a long rod with a handle. After ignition, the whistle is moved in a zigzag fashion by moving the handle by hand as in Figure 7.2 according to some musical notes. The whistle frequency varies as the hollow left in the left side of the whistle.

Figure 8 shows a multitubular whistle which changes frequency in three steps, consisting of three different whistles. These vary both in diameter and hollow length and are telescoped. When the first one (1) burns out, the second (2) is ignited, ejecting tube 1. Tube 2 burns with another frequency, then tube 3 burns in another.

Figure 9 shows a six-step multitubular whistle based on the same principle as shown in Figure 8.

A thunder whistle effect is obtained by the use of granular composition (Öztap 1965). The frequency of the sound is also changed by adjusting the hollow length by the outside tube B, sliding it against tube A (Fig. 5).

6. Applications of thrust to whistling rockets

A characteristic of a rocket using a whistle as the driver is that fins or sticks are not always necessary (Fig. 10). The upper part of the rocket is heavy with the charge and head block. The hollow part of the tube stabilizes the rocket's flight pattern with its light weight and internal gas flow. However, it is necessary to stabi-

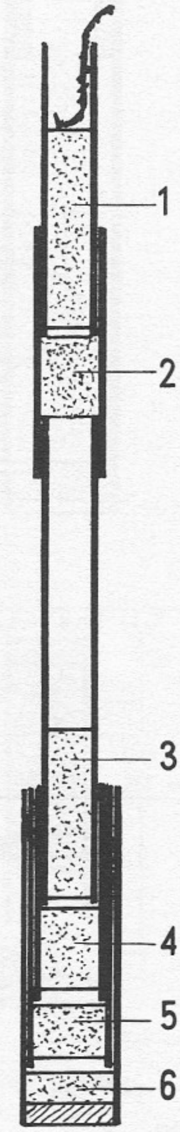

Figure 9. A six-step whistle.

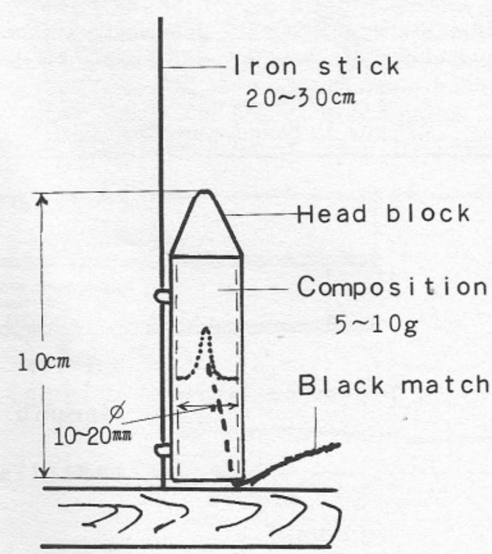

Figure 10. Whistling rocket.

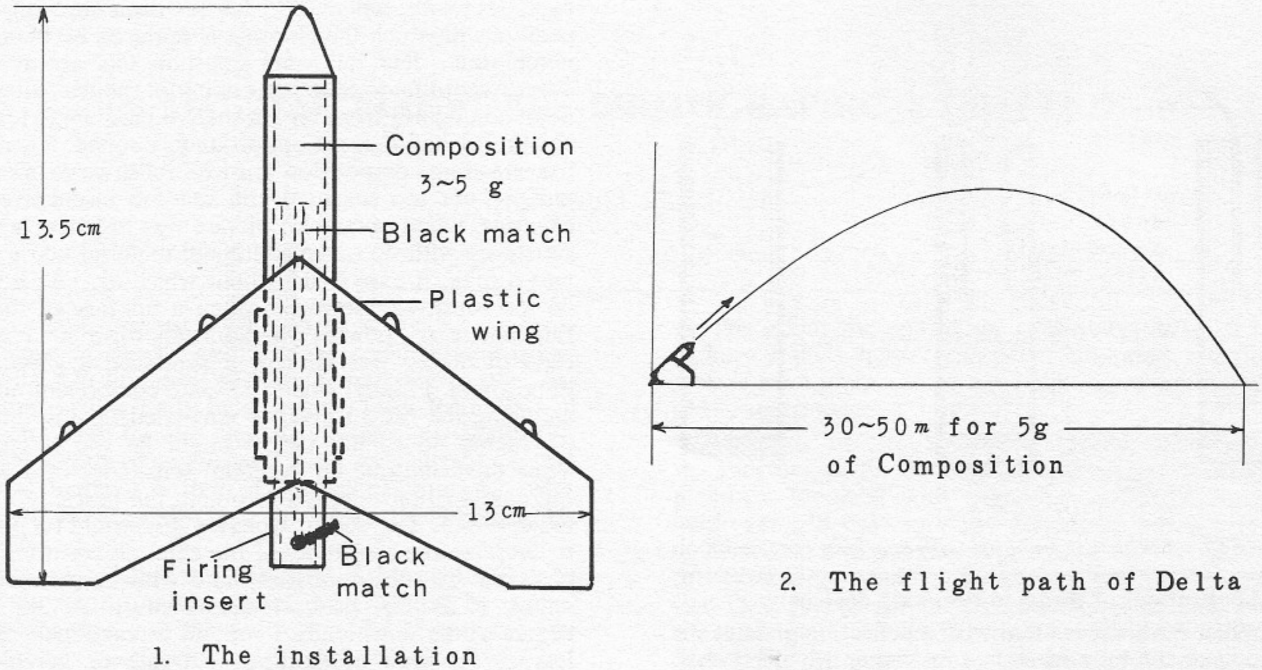

Figure 11. Delta toy aircraft.

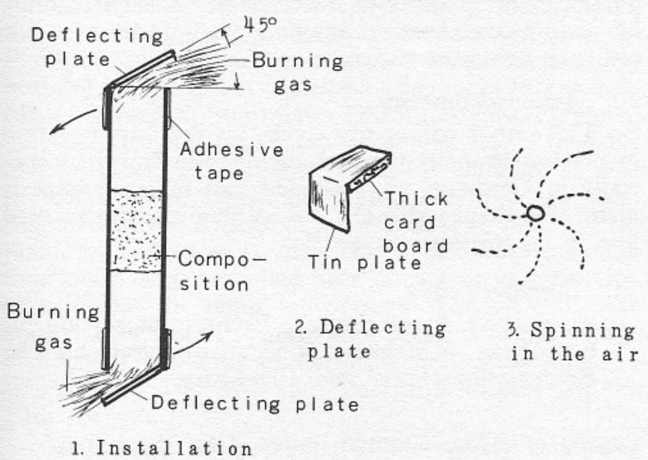

Figure 12. A whistling revolver by thrust inclination.

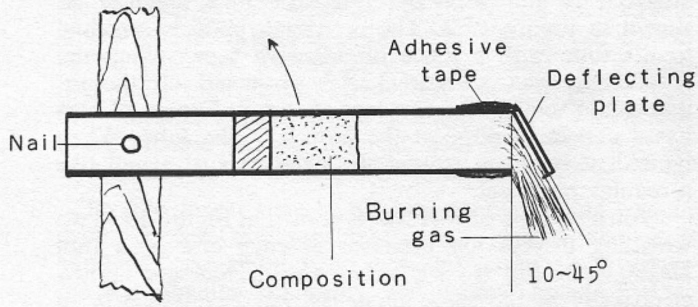

Figure 13. A whistling revolver around an axis by thrust inclination.

lize the initial launch by some device. Figure 11 shows a Delta toy aircraft which is propelled by a whistling driver. The firing insert stabilizes the flight just after the ignition, and it remains on the ground.

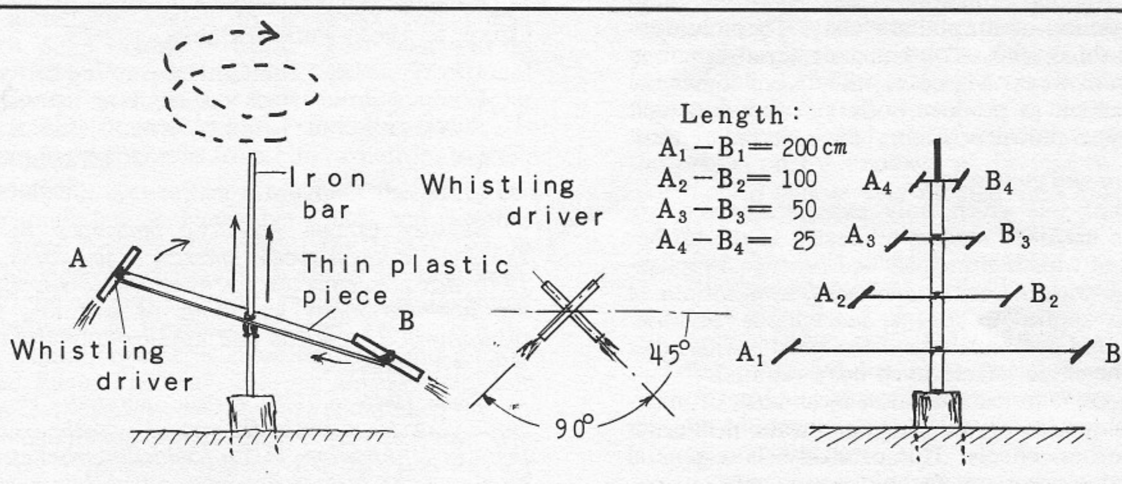

Figure 14. Revolvers with two whistling drivers.

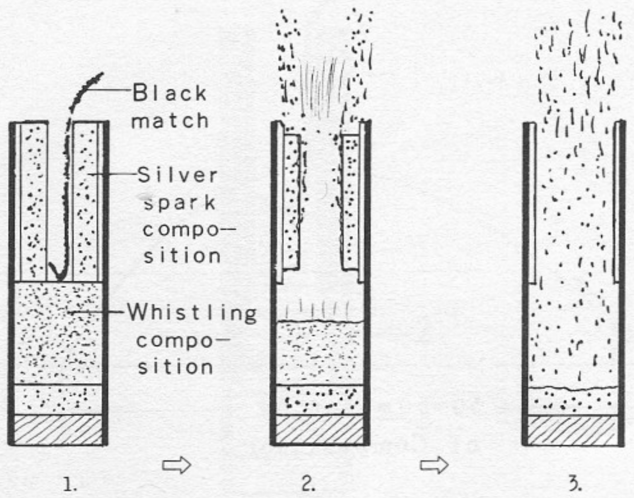

Figure 15. A whistle combined with sparking composition.

7. Applications of thrust to revolving devices

When a whistle is fitted with a deflecting plate at the opening of the tube as shown in Figure 12, it revolves because of thrust deflection. The surface of this thin, tin plate is protected from the hot burning gases which attack it by a cover of cardboard or other material, as shown in Figure 12.2. The deflecting plate is attached to the tube with a piece of adhesive tape. When the revolving device in Figure 12.1 is projected into the air, it revolves freely. The revolver shown in Figure 13 also has a deflecting plate at the mouth of the tube. When ignited, it revolves around the fixed axis of a nail like a regular pinwheel.

Another type of revolver is shown in Figure 14. Two whistling drivers are attached at each end of a thin plastic bar (Fig. 14.1). When the drivers are ignited electrically at the same time, the bar revolves around the vertical steel rod and the unit ascends upward. The axes of the two drivers cross a 90° angle. Figure 14.3 shows an installation which projects several whistling revolvers.

8. Combinations of whistles with light

Light from a whistle is very weak. The author tested whistle compositions containing 5, 10, and 15% magnesium, aluminum, or magnalium alloy. These compositions produced silver sparks, but their whistling sound and thrust were weak. Moreover, they were somewhat unsafe. Therefore, to produce both whistling and light effects, the type shown in Figure 15 is recommended.

9. Discussion and conclusion

The author has given only examples which are thought to be useful to readers interested in the further development of whistle principles and practice. Applications to music with batteries of whistles, applications of whistle thrust applied to saxons, tourbillions, or other type devices, and combinations of the whistle with other types of pyrotechnic effects have been omitted.

It is important to use the finest mesh sizes of materials when compounding whistling compositions in order to obtain the best effects. This of course is a general rule in manufacturing pyrotechnic noise items.

The author mainly considered compositions containing potassium chlorate with a lubricant as a desensitizer. However, since 1975 he has been studying compositions in which the chlorate is replaced by potassium perchlorate. The following question has arisen, however. According to Shimizu's opinion, the whistling phenomenon comes from an alternative oscillatory reaction of burning and detonation, producing sound. Therefore, the whistling composition must be sensitive to *some* extent — not too sensitive and not too insensitive. For example, when potassium picrate was tested as a single substance with no other additional material and pressed into a tube, it exploded without whistling, i.e., it might be too sensitive. However, when a mixture of the picrate and glass powder in atomized form in a weight ratio of 80/20 was ignited, it produced a good whistling sound. Finally, when the same component mixture changing the ratio to 60/40 was tried, it only burned, producing no sound; i.e., it might be too insensitive. Thus there may be an optimum sensitivity of a whistling composition required to obtain the best effect (Shimizu 1984). The author wonders if it would be possible to decrease the sensitivity of the chlorate whistling compositions by substituting chlorate with perchlorate, because, if Shimizu is correct, we must use the same degree of the sensitivities to obtain useful effects regardless of the type of oxidizer, chlorate or perchlorate. This problem may occur in manufacturing and handling whistling compositions, especially in large scale production. The quantity of composition in a batch must be restricted to smaller amounts than is the case for ordinary explosive mixtures.

10. Acknowledgments

The author wishes to express his deep appreciation to persons in many firework factories in Europe, especially in Germany, who assisted him in many experiments. He thanks also Dr. Takeo Shimizu who assisted him in completing this article.

11. Literature cited

Öztap, S. 1968. Pyrotechnische Brennstoffmischung zur Erzeugung pfeifender Töne, und Pyrotechnische Brennstoffmischung zur Erzeugung verschiedener Töne.

Öztap, S. 1976a. German Patent, GM 75 31 463.

Öztap, S. 1976b. Pyrotechnische Vorrichtung zur Erzeugung von kurzzeitigen Pfeif-Knall-Tönen.

Öztap, S. 1965. Turkish Patent, 12 928.

Shimizu, T. 1984. "The Critical Burning of Pyrotechnic Compositions." JOURNAL OF THE INDUSTRIAL EXPLOSIVES SOCIETY, vol. 45, no. 5. Japan.

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SELÇUK ÖZTAP *practices pharmacy in Istanbul, Turkey. He has a special interest in fireworks and since 1946 has concentrated on pyrotechnic whistles. Öztap has invented many variations of whistling fireworks, resulting in 27 patents and applications in Turkey and West Germany.*

From 1946 to 1970, Öztap operated a small factory employing 10 people. He mixed whistle compositions there in 10 kilogram lots for whistling rockets. In 1970 he closed the factory because of high labor costs. Since then, he has continued to develop new whistling compositions and devices in his own laboratory.