Optical Reproduction of Sounds from Negative Phonograph Cylinders

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Abstract. The laser-beam reflection method that has been developed for the reproduction of phonograph wax cylinders was applied to metallic negative cylinders called galvanos, for which the traditional phonograph cannot be used. To this end, a compact optical head consisting of a laser diode, a position sensitive device, and illumination and detection optics was developed together with drive and control units. Some valuable sounds were reproduced successfully by this system.

1 Introduction

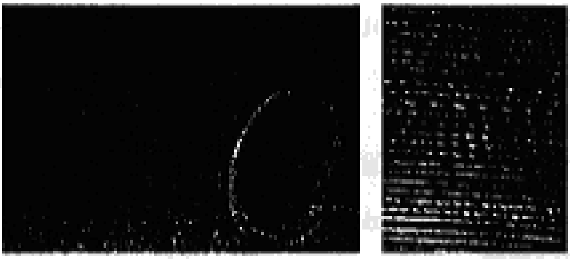
The invention of the phonograph by Thomas Edison has provided a first tool for recording sounds, and numbers of valuable recordings were made from the end of the 19th century to the beginning of the 20th. Many such recordings remain as phonograph wax cylinders, which can be reproduced by traditional phonographs as long as they do not have serious damages. To reproduce wax cylinders with serious damages, the laser-beam reflection method has been developed and applied successfully to various wax cylinders [1–4].

Recently, the authors come to know that many phonograph cylinders are preserved in Germany in the form of metallic negative cylinders in which folk music of various countries over the world are recorded. The negative cylinder was made by plating a wax cylinder with copper and, then, by melting down the original wax cylinder, being also referred to as *galvanos*. In this process, the sound is transferred into convex portions on its inside surface. Because of this, any stylus method is ineffective and those negatives have been left for a long time without investigations of the valuable sounds in them.

It is found, however, that the laser-beam reflection method developed for wax cylinders is effective also to the negatives. To apply the method to the negatives, some modifications were made and a new instrument was constructed. In this paper, we describe some features of the negatives and the developed *optical galvano player*.

2 Negative cylinders

Three negative cylinders were employed for the development of the instrument (Fig. 1(a)). They seem to be produced from typical wax cylinders and



(a) (b)

Fig. 1. (a) Negative cylinder. (b) Inside surface of the negative cylinder showing the height variation of the sound bank which is a replica of the sound groove of the original wax cylinder

have nearly the same dimension of 56, 54 and 110 mm in the outer and inner radii and length, respectively. The typical rotation rate was 144 and 160 rpm, and a sound of 2–3 min is encoded in the inside surface of each cylinder as a spiral *bank* with a pitch of 1/100 inch (Fig. 1(b)).

3 Principle of the reproduction

The principle of the laser-beam reflection method is shown schematically in Fig. 2. In case of the negative, the sound is encoded as a height variation of the surface of the sound bank. Suppose a laser beam incident on the center

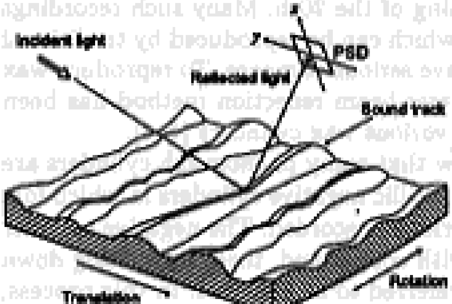


Fig. 2. Principle of the laser-beam reflection method. As the cylinder rotates, the reflection direction varies in the x-direction due to the height variation of the sound bank (sound track). The deviation of the illumination spot from the center of the sound bank gives the variation in y-direction

of the sound bank. The beam is reflected according to the reflection law and impinges a detection plane (xy-plane) perpendicular to the optical axis. With a rotation of the cylinder, the illuminating position in the xy-plane moves along the x-axis. In fact, the x-coordinate of this illuminating position is proportional to the tangent of the sound bank at the illumination spot and gives the sound signal. On the other hand, if the illumination spot deviates from the center of the bank, the reflected beam digresses in the y-direction, which gives a signal for the tracking error and can be used to compensate the deviation of the illuminating spot by adjusting the translation speed of the cylinder. These two signals in the x- and y-directions can be detected independently by setting a two-dimensional position sensitive device (PSD).

4 Optical system

To apply the above principle to the negative cylinder, a compact optical system that can be inserted into the cylinder is required. A schematical diagram and a photograph of the optical head we have constructed are shown in Figs. 3 and 4, respectively. A laser beam from a laser diode LD with the wavelength of 670 nm is guided by mirrors M_4, M_3, M_2 and M_1, and a beam splitter HM to a lens L_1, which converges the beam to the inside surface of the cylinder. The beam reflected from the cylinder surface goes back through the same part of the system up to HM and, then, is led by the lens L_2 to the PSD. A pinhole P is placed at the focal plane of L_2, where the image of the cylinder surface is formed, and passes only the image of the illuminating spot, thus rejecting effectively the stray light due to multiple scattering and reflection inside the cylinder.

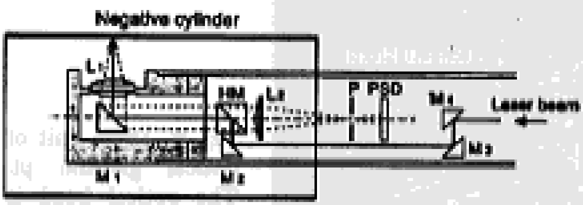


Fig. 3. Schematic diagram of the optical head. The lens L_1, mirrors M_1 and M_2, and beam splitter HM are common to the illumination and detection optics

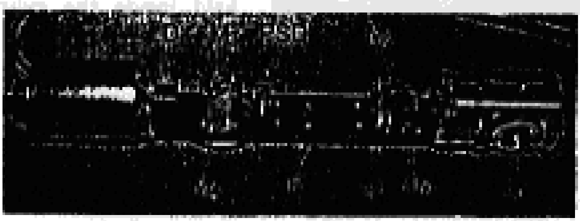


Fig. 4. Photograph of the optical head with the cover removed for display. The mirror M_1 is not seen in this photograph. P indicates the position of the pinhole which is unmounted in this image

5 Reproduction system

A schematic diagram of the developed system which may be called *optical galvano player* is shown in Fig. 5. The system consists of the drive and control units, the optical head being mounted on the former. A photograph of the drive unit is shown in Fig. 6. This system has two tracking modes: the auto-tacking mode and the constant translation mode. The former utilize the tracking-error signal to keep the tracking of the laser beam along the sound bank, while in the latter the cylinder is translated with a constant speed determined by the rotation rate of the cylinder. The rotation rate is adjustable in the range of 140–160 rpm.

Using this system, we reproduced successfully the sounds from some negatives including performances of Japanese musical instruments, *shamisen* and

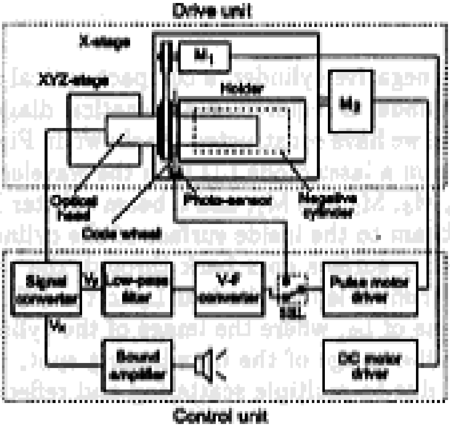


Fig. 5. Diagram of the optical galvano player. The system consists of the drive and control units. The DC motor M_1 rotates the holder while the pulse motor M_2 drives x-stage. The signal converter processes the output of the PSD and yields the sound and tracking error signals, V_s and V_y. V_s is amplified and drives the speaker, while V_y is sent to the pulse motor driver via the low-pass filter and V-F converter (auto-tacking mode). The pulse motor can also be controlled by the signal from the photo-sensor (constant translation mode)

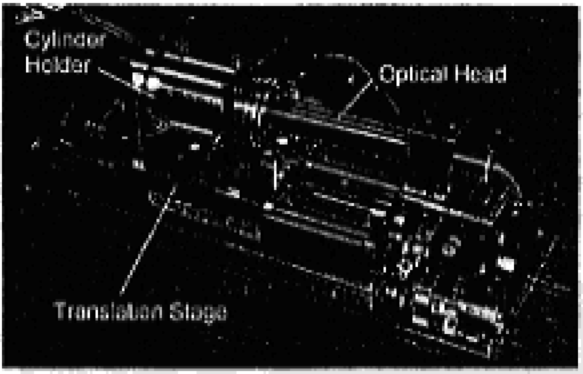


Fig. 6. Drive unit of the optical galvano player. The optical head is inserted into the negative held inside the cylinder holder which is mounted on the translation stage (x-stage)

koto, which were recorded in Berlin in 1901. The reproduced sounds have much better quality than existing wax cylinders. This is partly because wax cylinders currently available have been played many times and worn out considerably while the negatives preserve the initial quality of their original wax cylinders. The present instrument is expected to be used for revealing valuable sound information that has been left unknown for long time.

References

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