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Rose et al. [45] **Nov. 6, 1973**

[54] **APPARATUS FOR RECORDING SOUND ON MICROFICHE**

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[52] **U.S. Cl.**.. **179/100.3 B,** 178/DIG. 2, 178/6.7 R, 350/96 B
[51] **Int. Cl.**......................... **G11b 7/12,** H04m 5/84
[58] **Field of Search**........... 179/100.3 B, 100.2 MD, 179/100.2 T; 178/6.7 R, 6.7 A, 6.6 A, DIG. 2; 350/96 B; 250/219 Q, 219 QA, 219 FT, 219 D, 219 FR, 227

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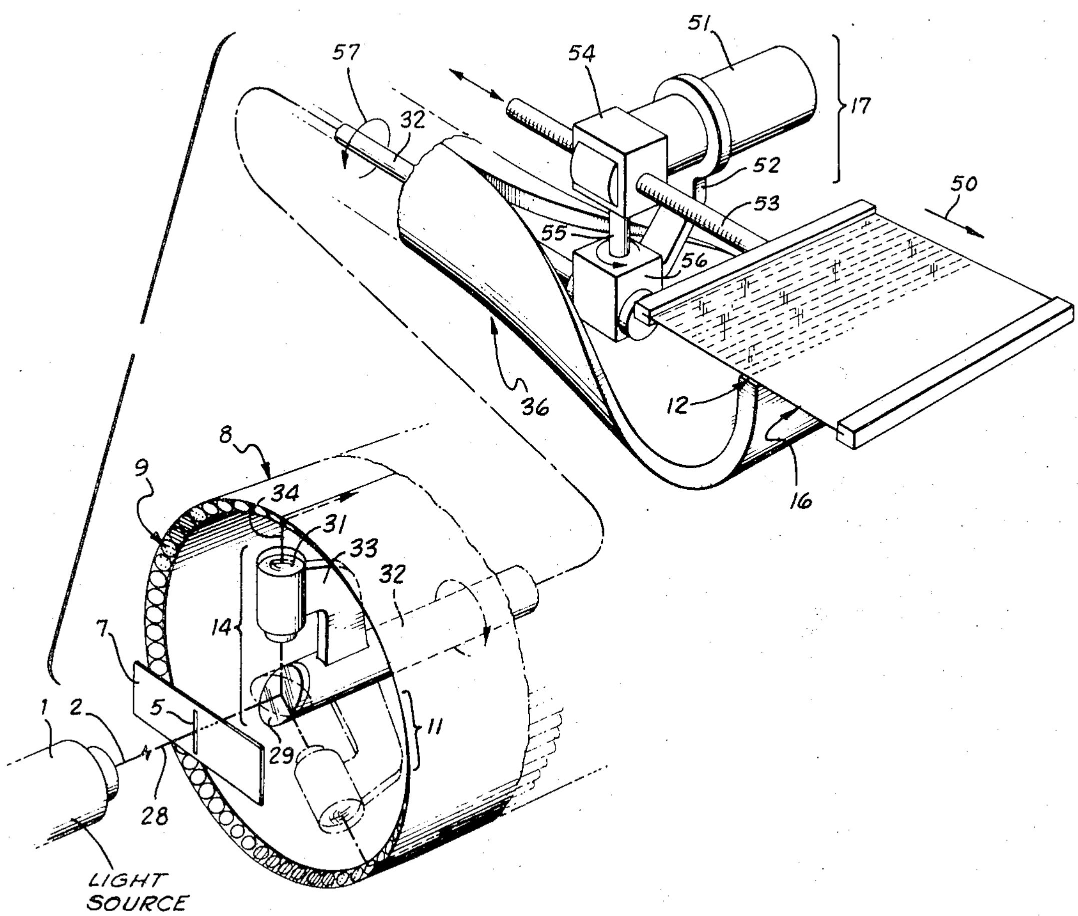
Primary Examiner—Raymond F. Cardillo, Jr.
Attorney—James R. Cypher

[57] **ABSTRACT**

An apparatus consisting briefly of a laser means for generating a beam of coherent electromagnetic radiation a record disc player or magnetic tape player for producing a signal to be recorded, a modulator for receiving the beam and the signal; an extinction control operatively connected to the modulator; a member having a slit therein for passing the modulated beam, a circular to linear scanner consisting of optic fibers; a recording member in microfiche format and apparatus for moving the recording member during the recording process.

1 Claim, 8 Drawing Figures



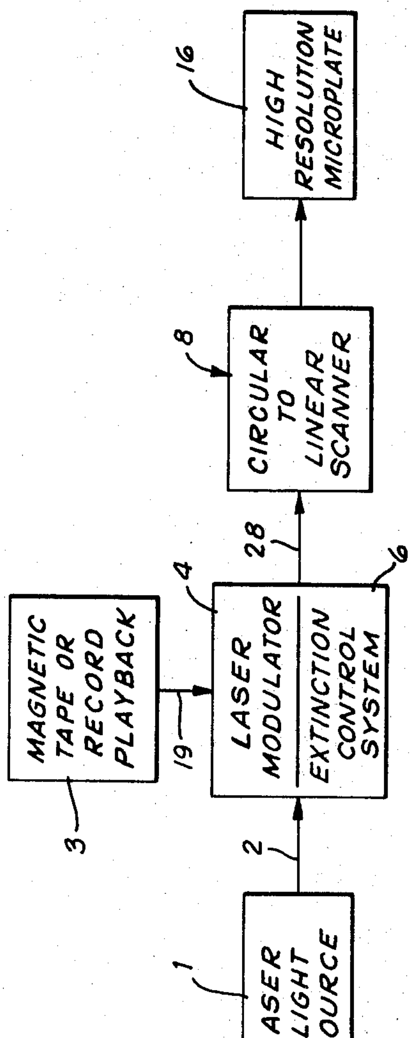

MAGNETIC TAPE OR RECORD PLAYBACK
LASER LIGHT SOURCE
LASER MODULATOR
EXTINCTION CONTROL SYSTEM
CIRCULAR TO LINEAR SCANNER
HIGH RESOLUTION MICROPLATE
1
2
3
4
6
8
16
19
28

FIG_1

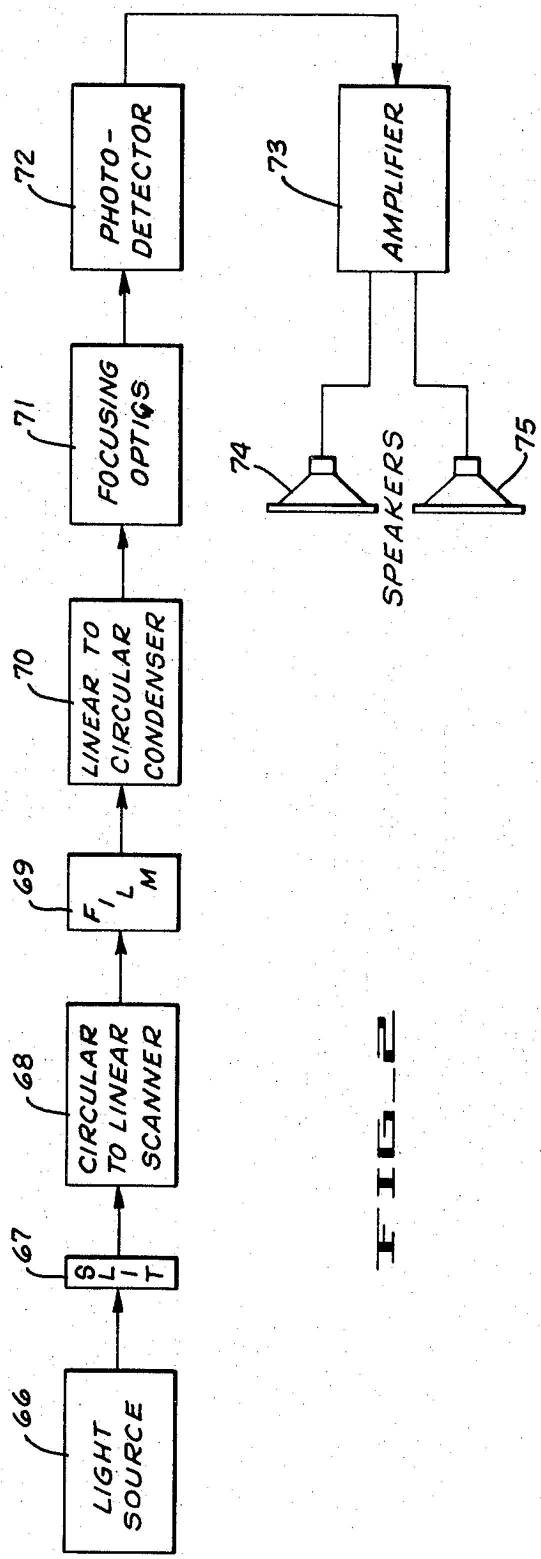

LIGHT SOURCE
SLIT
CIRCULAR TO LINEAR SCANNER
FILM
LINEAR TO CIRCULAR CONDENSER
FOCUSING OPTICS
PHOTO-DETECTOR
AMPLIFIER
SPEAKERS
66
67
68
69
70
71
72
73
74
75

FIG_2

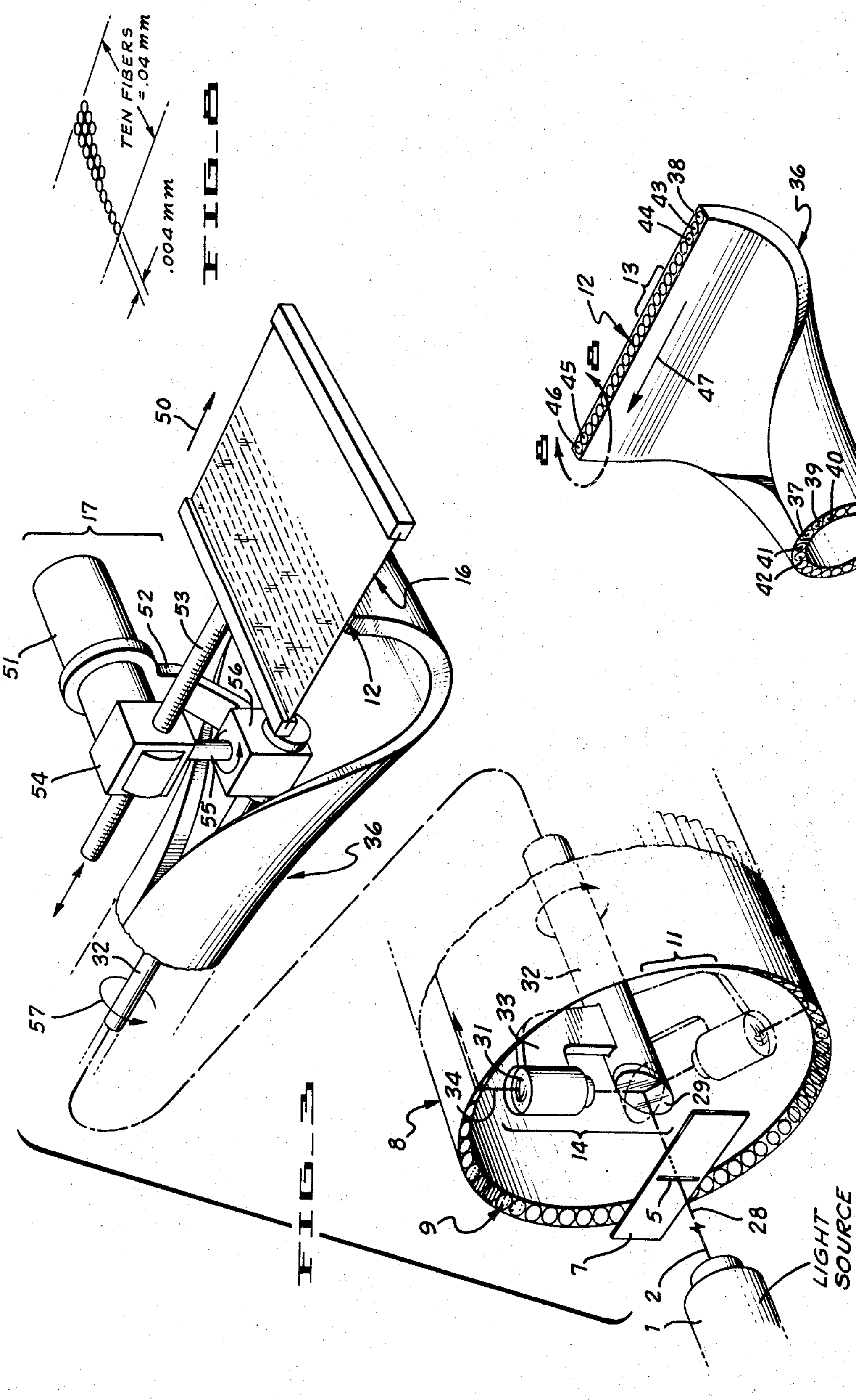


FIG. 8

FIG. 3

FIG. 4

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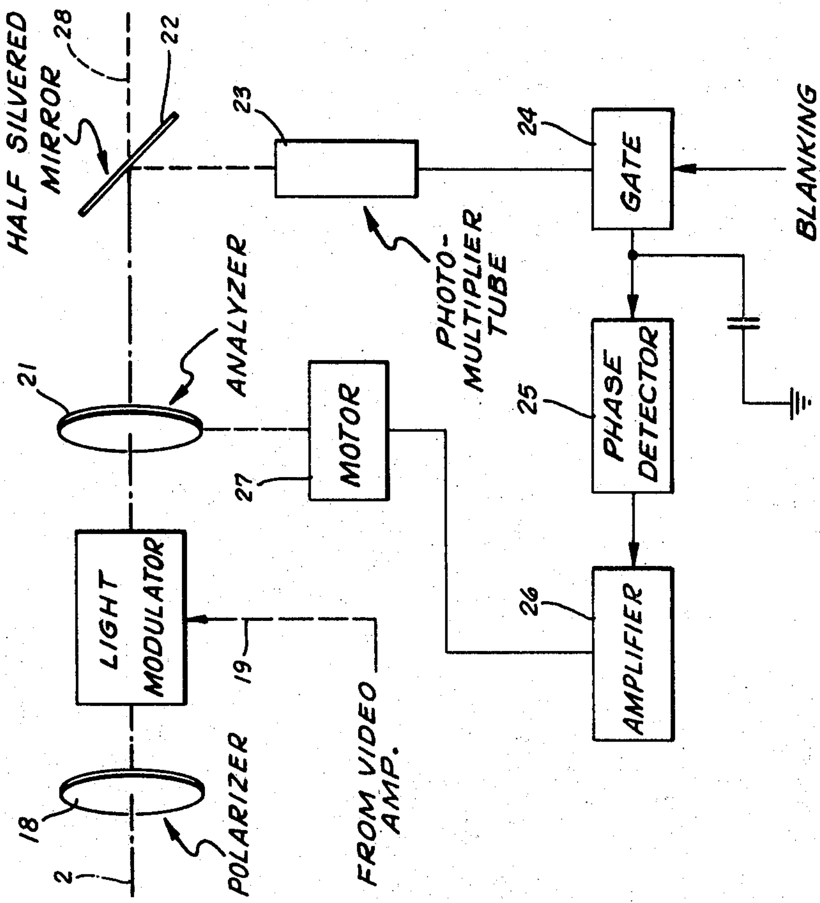

FIG_7

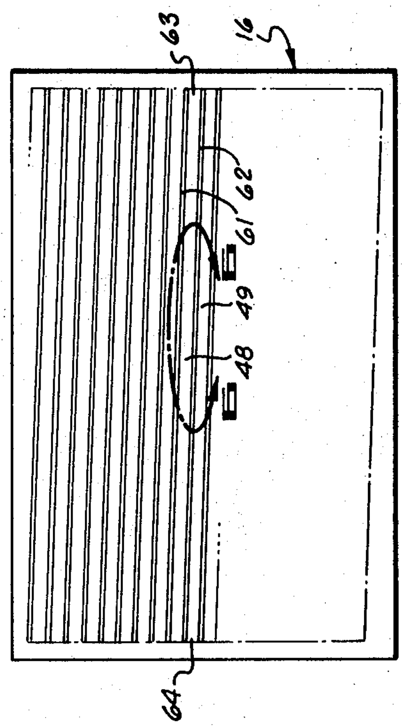

FIG_5

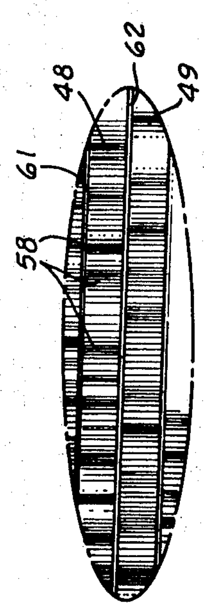

FIG_6

APPARATUS FOR RECORDING SOUND ON MICROFICHE

BACKGROUND OF THE INVENTION

For many years, optical sound reproduction means have been used to record the sound tracks on the films used by commercial theaters. These sound tracks have not been of the high fidelity achieved by magnetic tapes and are therefore limited in use. Further, present optical sound reproduction has only been used on reel to reel film.

Thus far, magnetic tape is still dependent upon moving an elongated strip of tape from one reel across a head to another reel. The use of tapes presents a storage problem for persons with extensive libraries. More importantly, the use of relatively inexpensive recording equipment has made it all too easy for many people to record their own magnetic tapes from radio programs or from one reel to another, thus in many cases defeating the rights of copyright holders by making illegal copies without a license and depriving composers, recording artists and publishing companies from royalties and profits on repeat sales of a particular recording.

SUMMARY OF THE INVENTION

The gist of the present invention is the use of highly sophisticated optic sound equipment to reduce sound patterns to micro-size so that they can be recorded and reproduced on film of micro size thereby making it extremely difficult for illegal reproductions and yet bring additional benefits to the person with playback equipment in the form of reduced storage problems for music libraries, and higher fidelity and longer lasting recordings.

A further advantage of the present invention is the ability to reproduce quantities of microfiche films inexpensively and quickly once the initial investment of the equipment is made.

Another feature of the present recording equipment is to help authors secure for the statutory limited time the exclusive right to their respective writings as guaranteed by Article 1 Section 8 of the Constitution.

Still another feature of the present invention is to provide a system which is compatible with presently existing recording equipment; is capable of reproducing variants in number of sound tracks on the microfiche and can utilize major components of existing equipment in the recording system.

A still further advantage is a system of recording sound on micorfiche through the use of photographic gradations of light reduced to micro-size.

Still another advantage is a recording system which will equal or surpass existing recording systems in fidelity, and produce recordings on a microfiche which can then be used in relatively inexpensive playback equipment which equals or exceeds high fidelity magnetic tape but at less cost.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of the system used for recording using the apparatus of the present invention.

FIG. 2 is a schematic diagram of the apparatus used in the playback of the recordings made by the present equipment and described in my co-pending U.S. Pat. application Ser. No. 246,354 filed Apr. 21, 1972.

FIG. 3 is a perspective view of a portion of the apparatus of the present invention with a portion separated from the body of the main portion of the apparatus and rotated 90° to more clearly show the inner workings of the device. A dash-dot line indicates the proper assembly of the apparatus.

FIG. 4 is a perspective view of a portion of the device set forth in FIG. 3.

FIG. 5 is a plan view of a microfiche showing the format of the recording indicia thereon.

FIG. 6 is a greatly enlarged view of a portion of the microfiche shown substantially along the line 6—6 of FIG. 5.

FIG. 7 is a diagram of an example of an extinction control system.

FIG. 8 is a greatly magnified portion of the optic fibers taken along line 8—8 of FIG. 4.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The recording apparatus of the present invention consists briefly of means **1** for producing a beam **2** of coherent electromagnetic radiation; means **3** for producing a signal to be recorded; modulating means **4** receiving the beam of coherent electromagnetic radiation and the signal to be recorded and creating an optical image; extinction control means **6** operatively connected to the modulating means to prevent amplitude modulation drift, wherein the improvement comprises: a member **7** having a slit **5** therein for passing the modulated beam of coherent electromagnetic radiation therethrough; a plurality of optic fibers **8** arranged with their first ends **9** in a closed curvilinear line **11** and their second ends **12** in an open line pattern **13**; optical means **14** mounted adjacent the slit for sequentially projecting the beam upon each of the first fiber optic ends; an elongated recording member **16** movably located adjacent the second ends of the fibers for receiving and retaining the image thereon; and means **17** for moving the recording member during the recording process.

The light source for creating the beam of coherent electromagnetic radiation is a monochromatic laser. A continuous emission gas laser such as a 100 milliwatt helium-neon gas laser is suitable.

The modulating means **4** changes the orientation of the plane of polarization of the light transmitted by the laser **1** through the polarizer **18** as a function of a modulating signal such as a signal **19** applied to the light modulator **4** from a source such as a magnetic tape or record playback **3**.

An extinction control system **6** is operatively connected to the light modulator. An example of an extinction control system is described in U.S. Pat. No. 3,562,422, the major parts of which are set forth in FIG. 7. Briefly, the system consists of an analyzer **21**, a half silvered mirror **22**, a photo-multiplier tube **23**, a gate **24**, a phase detector **25**, an amplifier **26** and a motor **27**.

From the half silvered mirror, the modulated beam **28** passes through the slit **5** and is reflected from mirror **29** to lens **31**. The mirror **29** may be formed on or connected to the end of a rotating shaft. It is to be understood that the optic means **14** could be a prism or any other means for changing the direction of the beam for entry into the optic fibers. As shown in FIG. 3, the mirror **29** is mounted at an angle so that the beam **28** is reflected at an angle into lens **31**. The deflected beam is then focused into the ends of the optic fibers by a lens which reduces the image by **10** times or more. The lens may be connected directly to the shaft **32** by a bracket **33** for rotation therewith. The reflected and reduced modulated beam **34** is focused on the first ends **9** of the optic fibers. As shown in the drawings, the ends are polished flat faces angularly related to the initial longitudinal direction of the fibers. Where the initial longitudinal axis of the fibers is parallel to the axis **32,** the end faces are formed at a **45** degree angle.

The projected image of the slit is transferred by the coherent fiber optics characteristic of the circular to linear scanner shown generally in FIGS. **3** and **4** and designated by the number **8.** The light enters fiber end **37** and emerges at fiber end **38.** In like manner, the light enters ends **39, 40,** travels around the entire circle, ending at **41** and **42** and emerges respectively at ends **43, 44** and across the line to ends **45** and **46.** Thus the image of the slit is presented to the recording member **16** as a small light bar moving from right to left as indicated by arrow **47** at a speed directly proportional to the mirror rotation and with no return time. The instant the light disappears from end **46,** it appears in end **38.** FIG. **5** shows the recording member **16,** hereafter referred to as a microplate. FIG. **6** shows a portion of the recorded image greatly magnified. Portions of two lines **48** and **49** are shown. The actual width of the recorded lines is purely a function of the size of the slit, the power of the microscope objective, the size of the optical fibers, and the resolution of the film, as it is the frequency resolution capability of the system.

The microplate **16** is constantly moved in the direction shown by arrow **50** by various mechanisms **17.** As an example, an electric motor **51** mounted on bracket **52** turns threaded rod **53** by means of a worm gear box **54** which also is a right angle drive and rotates shaft **55** through right angle drive **56** which turns shaft **32** in the direction shown by arrow **57** which rotates the mirror **29** and lens **31.** Thus the rotation of the mirror **29** is synchronized with the movement of the microplate **16.**

Referring to FIG. **6,** the image of the modulated beam appears on the microplate as a series of shaded lines **58** which are spaced at varying intervals. Each series of lines is separated by spaces such as are designated by the numbers **61** and **62.**

The ability of the system to record on a flat surface as a series of lines without any interruption in the recording may be understood by reference also to FIGS. **3, 4** and **5.** As the microplate moves slowly in the direction of the arrow **50,** the bar of light moving in the direction of the arrow **47** across the end of the scanner causes a series of lines such as **48** and **49** to be formed at an angle to the sides of the microplate. Thus as the light ends at line end **63** of line **48,** it reappears instantly at the line beginning **64** of line **49.** The distance moved by the microplate is equal to twice the length of the slit image on the microplate indicated by number **58.** This allows the next scanning to start immediately underneath the previous line.

The light patterns, reduced to micro photographic images, are recorded on high resolution film. As an example, the film should resolve about 1,000 lines per milimeter. Such resolution will produce sound recordings with low distortion factors and high fidelity characteristics, equal or superior to the state of recording art presently achieved through disc, or magnetic tape sound reproduction.

The microplate could be of any shape as long as the end of the scanner was shaped to a similar configuration. The simplest form and certainly the easiest from the standpoint of storage is to form the microfiche in a flat plane about 4 inches by 6 inches. Thus the second ends of the optic fibers are mounted in a plane substantially parallel to the recording surface of the recording member.

Upon completion of the recording, the microplate is developed and contact printed into high resolution microfilm sheets known as microfiche.

The playback apparatus is described in our U.S. Pat. application Ser. No. 246,354 filed concurrently herewith on Apr. 21, 1972. Briefly, the playback is shown in FIG. **2** and consists of a light source **66** which generates a beam of light which passes through a slit **67** which is projected onto a circular to linear scanner **68.** The beam of light travels a bar of moving light across the microfiche **69.** The light patterns from the film are transmitted by a linear to circular condenser **70** focused by optics **71** and picked up by a photo-detector **72** which activates an amplifier system **73.** The sound emerges through speakers **74** and **75.**

In order to be commercially practical, the playing time of the recording should be at least 30 minutes. This parameter is easily achieved by the microfiche format. If the line length is 6 inches, the slit width is 0.001 inches × 0.020 inches, the objective power is ten times and the fiber diameter is 0.0001 inches and the plate resolution is 500 lines per millimeter giving a line width of 0.00008 inches, the frequency modulation capability is 60,000 cycles per 6 inch line. Scanning at a rate of 60 lines per minute there is an equivalent frequency response of 60,000 cycles per second. The slit length of 0.020 inches has a capability of recording 2,000 lines in 4 inches which at a scanning frequency of one line per second represents a total recording time of 33 minutes.

The resolution requirements for the microfiche film may be calculated as follows: Assuming the size of the microfiche is to be 4 inches by 6 inches with the recording across the 6-inch dimension, and a maximum frequency of 30,000 cycles across the 6 inches and a playback time of 20 minutes at one line per second, the cycle width at 30,000 cycles is calculated as follows. The line width of 6 inches is divided by 30,000 cycles and this gives a cycle width of 2×10^{-4} inches. The resolution requirements are therefore calculated by dividing 1 inch by the cycle width of 2×10^{-4} and the conversion factor of 25.4 which equals 198 lines per millimeter. This is well within the resolution requirements of the microfiche film which at the present time is about 300 lines per millimeter.

The line width for a 20 minute playback, assuming that each line is scanned in 1 second, is calculated by dividing the 4-inch length of the card by 20 minutes × 60 seconds per minute, or a line width of 3.33×10^{-3} inches. The resolution requirement of the line width is therefore calculated by dividing 1 inch by $3.33 \times 10^{-3} \times 25.4$ (the conversion factor) giving a resolution factor of **12** lines per millimeter.

The optical fiber size of 5.08×10^{-4} millimeters is calculated, using the following assumptions: For a 3 percent distortion at 10,000 cycles, the slit width should be equivalent to one-thirtieth of the cycle width at that frequency. The cycle width at 10.000 cycles is calculated by dividing 6 by 1×10^4 giving a cycle width of 6×10^{-4} inches. The slit width for a 3 percent distortion is therefore arrived at by dividing 6×10^{-4} by 3×10 giving a slit width of 2×10^{-5} inches. The size of the fiber is obtained by looking to the slit width. This is calculated by multiplying the slit width of 2×10^{-5} by 25.4 (the conversion factor) giving a size of fiber of 5.08×10^{-4} millimeters in diameter.

The film advancement speed is obtained from the previous calculations wherein the rate of scanning is to be one line per second with a line width for a 20-minute playback of 3.33×10^{-3} inches. The advancement speed is therefore obtained by multiplying the line width of 3.33×10^{-3} by 60 giving a speed of 0.1998 inches per minute.

The speed at which the mirror is turning is 60 revolutions per minute which is obtained by the assumption that the scanning time for each line is 1 second.

Referring to FIG. **8,** which shows a greatly magnified portion of the ends of the fiber optics **8** in the circular to linear scanner, each of the individual fibers is about 0.004 millimeters in diameter closely spaced in rows which are 10 fibers wide for an end width of 0.04 millimeters.

We claim:

1. An apparatus for recording sound patterns consisting of:

a. means for producing a beam of coherent electromagnetic radiation;

b. means producing a signal to be recorded;

c. modulating means receiving said beam of coherent electromagnetic radiation and said signal to be recorded and creating an optical image;

d. extinction control means operatively connected to said modulating means to prevent amplitude modulation drift, wherein the improvement comprises:

1. a member having a slit therein for passing said modulated beam of coherent electromagnetic radiation therethrough;

2. a plurality of optic fibers arranged with their first ends in a closed curvilinear line and their second ends in an open line pattern;

3. optical means mounted adjacent said slit for sequentially projecting said beam upon each of said first fiber optic ends;

4. an elongatd recording member movably located adjacent the second ends of said fibers for receiving and retaining said image thereon; and

5. means moving said recording member during the recording process.

e. said optical means including a mirror mounted for rotation for receiving said modulated beam and sequentially reflecting said beam upon each of the first ends of said optic fibers;

f. said optical means including a rotatable shaft connected to said mirror;

g. a lens mounted on said shaft for rotation therewith for receiving said reflected beam from said mirror, and reducing, focusing and projecting said beam sequentially upon the first ends of said optic fibers;

h. said first ends of said optic fibers being arranged in substantially a circle and the ends of said optic fibers having planar faces in a plane angularly related to the longitudinal axis of said optic fibers;

i. said plane of said mirror being angularly related to the longitudinal axis of said shaft; and

j. said means for moving said recording member being operatively connected to said shaft of said optical means for synchronizing the movements of said mirror, lens and recording member.

* * * * *