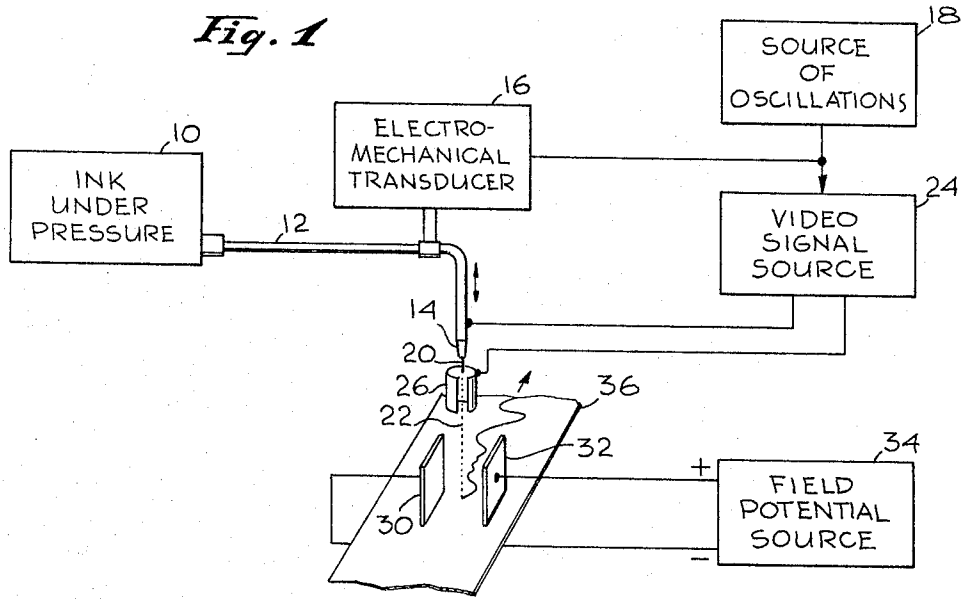
Oct. 25, 1966 R. A. ADAMS ETAL 3,281,860

INK JET NOZZLE

Filed Nov. 9, 1964

Fig. 1



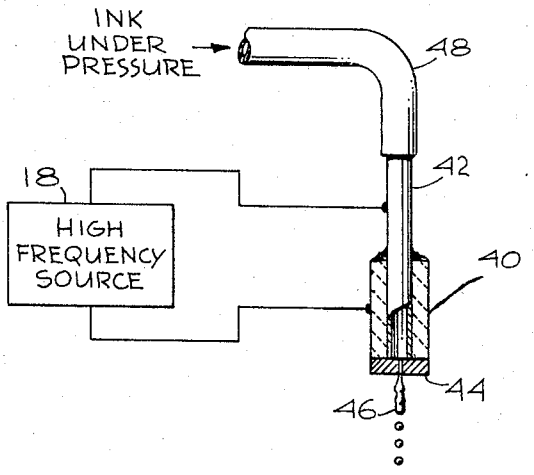


Fig. 2

INVENTORS
ROMAN A. ADAMS
VINCENT E. BISCHOFF
BY Samuel Lindenberg
ATTORNEY

United States Patent Office

3,281,860

Patented Oct. 25, 1966

3,281,860
INK JET NOZZLE

Roman A. Adams, Skokie, and Vincent E. Bischoff, Wheaton, Ill., assignors to A. B. Dick Company, Chicago, Ill., a corporation of Illinois

Filed Nov. 9, 1964, Ser. No. 409,831
3 Claims. (Cl. 346—75)

This invention relates to apparatus for producing the information represented by video signals, using ink drops deposited on a writing medium, and more particularly to improvements therein.

Apparatus has been developed for making a record on a writing medium of the information represented by video signals, by generating a stream of ink drops, directing these ink drops toward a writing medium and then deflecting these ink drops using video signals, in a manner so that when the ink drops do reach the writing medium, they represent the information contained in the video signals. The apparatus which is employed for producing the ink drops consists of an ink reservoir in which there is ink under pressure. The ink reservoir feeds a pipe which is connected to a nozzle. An electromechanical transducer is employed to vibrate the nozzle at some suitable high frequency. The ink accordingly is ejected from the nozzle in a stream which shortly thereafter breaks into individual drops.

Because these drops are to be charged and thereafter deflected by electrical signals, it is desirable to make these drops have as uniform a size as possible. It is also desirable to form these drops with a close spacing, since the closer the spacing, the better the resolution which can be obtained. Also, it is desirable to form the drops into a small size so that the amplitude of the signals required to deflect these drops should not be excessive. A number of different constructions have been proposed for forming the ink drops such as a drawn glass tube which is vibrated by an external transducer, or a metal tube vibrated by some form of external transducer, or a magnetostrictive metal tube which is magnetostrictively vibrated. One of the problems with the foregoing types of transducers is that the range of frequencies over which they can be used is limited. Further, the power required to drive or vibrate the transducer is significant. This, therefore, requires a more costly high frequency current drive source than would be required with the present invention. Also, an electrolysis of the metal parts occurs as a result of a potential being applied across the ink and the metal tube which deteriorates the metal rather rapidly.

An object of this invention is to provide a novel and inexpensive construction for apparatus for forming a stream of ink drops.

Another object of the present invention is to provide a construction for an ink drop forming structure in which the effects of electrolysis are minimized.

Yet another object of the present invention is to provide a construction for an ink drop forming structure which can operate over a relatively wide range of frequencies.

Still another object of the present invention is the construction of a novel ink drop forming apparatus requiring a very small amount of driving power.

These and other objects of the invention may be achieved by forming the ink drop apparatus employing a piezoelectric crystal having a hole drilled therethrough. A metal tube is inserted in the hole and soldered to the piezoelectric crystal to form a permanent waterproof attachment therewith. The crystal and tube have one common end, and the tube extends from the other end of the crystal. An orifice washer is attached to the common end of the tube and crystal. The orifice washer merely comprises a metal washer having a very small opening

therethrough through which the ink is emitted under pressure. The driving electrical energy is applied to a contact on the outside surface of the metal tubing and to a contact on the outside surface of the piezoelectric crystal. The tubing applies the potential to the inside surface of the piezoelectric crystal. The assembly is then hermetically sealed.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a schematic drawing of an arrangement for an ink drop recording system in accordance with the prior art; and

FIGURE 2 illustrates ink drop forming apparatus in accordance with this invention.

In order to afford a better understanding of this invention, a schematic drawing of an ink drop recording apparatus, in accordance with the prior art, is shown in FIGURE 1. This apparatus comprises an ink reservoir **10** which contains ink under pressure. Tubing **12** is connected to the ink reservoir **10** and terminates in a nozzle **14**. An electromechanical transducer **16** vibrates the tubing and the nozzle in response to the output of the source of oscillations **18**. The source of oscillations may be an oscillator having a frequency which may vary from 5 kc. to 85 kc.

The electromechanical transducer **16** is vibrated substantially at the frequency of the source of oscillations causing the tubing and nozzle to vibrate whereby the ink stream **20** soon breaks down into ink drops **22**. A video signal source **24** which is synchronized by the source of oscillations is connected between the nozzle and the charging cylinder **26**. As a result, each of the ink drops, which should be of substantially the same mass, receives a charge, the amplitude of which is determined by the amplitude of the video signal applied from the source **24** and the charging ring **26**.

The charged ink drops, after passing through the charging ring, pass into a static electric field which is established between two plates respectively **30**, **32** which are connected to a field potential source **34**. As a result of the action between the field and the charge on each drop, the drops are deflected from their center line path between the plates in accordance with the charge which they carry. Thus, when they fall finally on a writing medium **36** which is moving past the plates, a mark occurs on the writing medium in ink representative of the information in the video signals.

It should be appreciated from the foregoing brief description of the prior art, that the drop spacing should be uniform, the size of the drops should be small and the spacing between the drops should be close.

In FIGURE 2, there is shown an arrangement in accordance with this invention of drop forming apparatus. FIGURE 2 is a cross-section of an embodiment of the invention. It comprises a piezoelectric crystal **40** which has a hole drilled therethrough for the insertion therein of metal tubing **42**. The end of the metal tube and of the piezoelectric crystal are made to coincide. The tubing and the piezoelectric crystal are soldered together to form a permanent waterproof attachment. The coincident ends of the crystal and the tubing are covered with a washer **44** which is termed an orifice washer. This washer has an opening **46** drilled therethrough through which the ink is emitted under pressure. The source of oscillations **18** is connected between the outside of the metal tubing **42** and the outside of the piezoelectric crystal

40. The end of the tubing which is not covered by the orifice washer is attached to a flexible tubing 48 which connects to the ink reservoir 10. The assembly may then be hermetically sealed.

The piezoelectric crystal excites the tubing enough to break up the steady liquid flow of ink which is emitted from the orifice, into discrete droplets at a wide range of frequencies below the unit's resonant frequency. The hermetic sealing operates to protect against electrolysis.

It has been found that a very small amount of power is required to drive the apparatus. The resulting apparatus may be made very small. It may easily be duplicated using machine-made parts. The construction is such that hermetic sealing can be employed which protects against electrolysis and atmospheric conditions. The apparatus has the further advantage that in view of the frequency range made possible by the direct insertion of the tubing within the driving crystal, higher frequencies of drop formation are made possible. The drop spacing furthermore is reduced to two-drop diameters which improves the printing performance. Finally, it has been found, from the operation of an embodiment of the invention which was built, that much smaller drops result from this apparatus than were thought possible from the relatively large orifice size of the washer. As a result, the size of the orifice can be made larger than thought necessary resulting in the reduction of pressure requirements and minimizing the possibility of the clogging of the orifice.

There has accordingly been described and shown herein a novel and useful ink drop forming apparatus.

What is claimed is:

1. An ink drop forming apparatus comprising an electromechanical transducer having an opening therethrough, hollow metal tubing positioned within said opening and extending therefrom, said metal tubing and transducer having one of their ends coextensive, means attaching said tubing and transducer to one another, a washer having an opening therein, means attaching said washer to said coextensive ends of said metal tubing and transducer, and means for applying excitation between the inner and outer surfaces of said electromechanical transducer.

2. An ink drop forming mechanism according to claim 1 wherein said electromechanical transducer is a cylindrically-shaped piezoelectric crystal.

3. Apparatus for forming drops of ink at a predetermined frequency comprising a cylindrical piezoelectric crystal having a hole through the center thereof, a cylindrical metal tubing extending into said hole and having one end thereof coextensive with one end of said cylindrical piezoelectric crystal, solder means fastening said crystal and tubing together, a metal washer having a central opening, means attaching said metal washer to said crystal and tubing at the coextensive ends thereof, and means for applying excitation to said crystal including a first terminal means on the outside surface of said crystal and a second terminal means on the outside wall of said tubing.

References Cited by the Examiner

UNITED STATES PATENTS

2,512,743	5/1950	Hansell	346—132 X
2,908,443	10/1959	Fruengel	239—4 X

FOREIGN PATENTS

898,848	6/1962	Great Britain.

RICHARD B. WILKINSON, *Primary Examiner.*