PERMANENT RECORD SPARK DETECTOR

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ABSTRACT: A spark detector with a thin metallic film as cathode was developed for possible use in magnetic spectrographs. The spark sputters away material from the cathode, leaving a clearly visible hole, allowing easy scanning. Optimum cathode thicknesses were determined for copper and gold cathodes, and a study was made of hole sizes and shapes. It is also pointed out that this technique may be useful for studying the mechanism of the spark, in particular the streamer theory, and the sputtering from the cathode.

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Over the past few years several efforts have been made to replace the nuclear track plates in magnetic spectrographs, by arrangements that will either produce immediate information, or will simplify later scanning[1]. As part of these efforts, we have studied the possibility of using a spark detector instead of the plates; however, instead of using the spark chamber's sonic properties[2], the cathode is formed by a thin metallic film deposited on glass, so that the material sputtered away by the spark leaves a hole visible even to the naked eye. This could considerably simplify automatic or visual scanning.

The tests were carried out with a conventional spark detector except for the cathode, which could be easily removed and replaced by the appropriate metallic film. For optimizing operating conditions, the anode to cathode distance could be varied, as well as the distance to the ^{241}Am alpha source. In air at atmospheric pressure, and 1.5 mm anode-to-cathode separation, the detector plateau was between 2400 and 4000 volts, with a slope of 5% per 100 volts.

Gold and copper cathodes, evaporated onto glass slides, with different film thicknesses were used. To make sure that all sparks produced holes, a comparison of counts in an associated scaler was made with the number of holes observed by microscope. In this way the following convenient cathode thicknesses were determined: 50 to 120 $\mu gr/cm^2$ for copper, and 80 to 150 $\mu gr/cm^2$ for gold. For thicker cathodes there is not enough sputtering to produce holes. In the thinner cathodes the holes are irregular in shape. Also, for a given thickness, the average hole size grows with increasing applied voltage.

Within the operating ranges mentioned, the hole diameter is quite constant at a given voltage, so that the amount of material removed from the cathode is linear with cathode thickness. Above these values, the diameter could not be measured. Below, the holes are not only irregular in shape, but of large size, up to twice normal in area, as shown in the photographs of figure 1.

The streamer mechanism[3] is generally accepted for sparks. This phenomenon would normally be affected by detector geometry and by external circuitry. In the case of thin cathodes, however, one has to consider the possibility that there is not enough material available to support the spark, thus changing its duration, and the pulse shape produced. A resulting sideways overflow of the streamer would account for the irregular shapes and large sizes of the cavities for small thicknesses. A systematic study using this technique, plus a close observation of the pulses produced and a careful control of external circuits, could give useful information of the streamer mechanism.

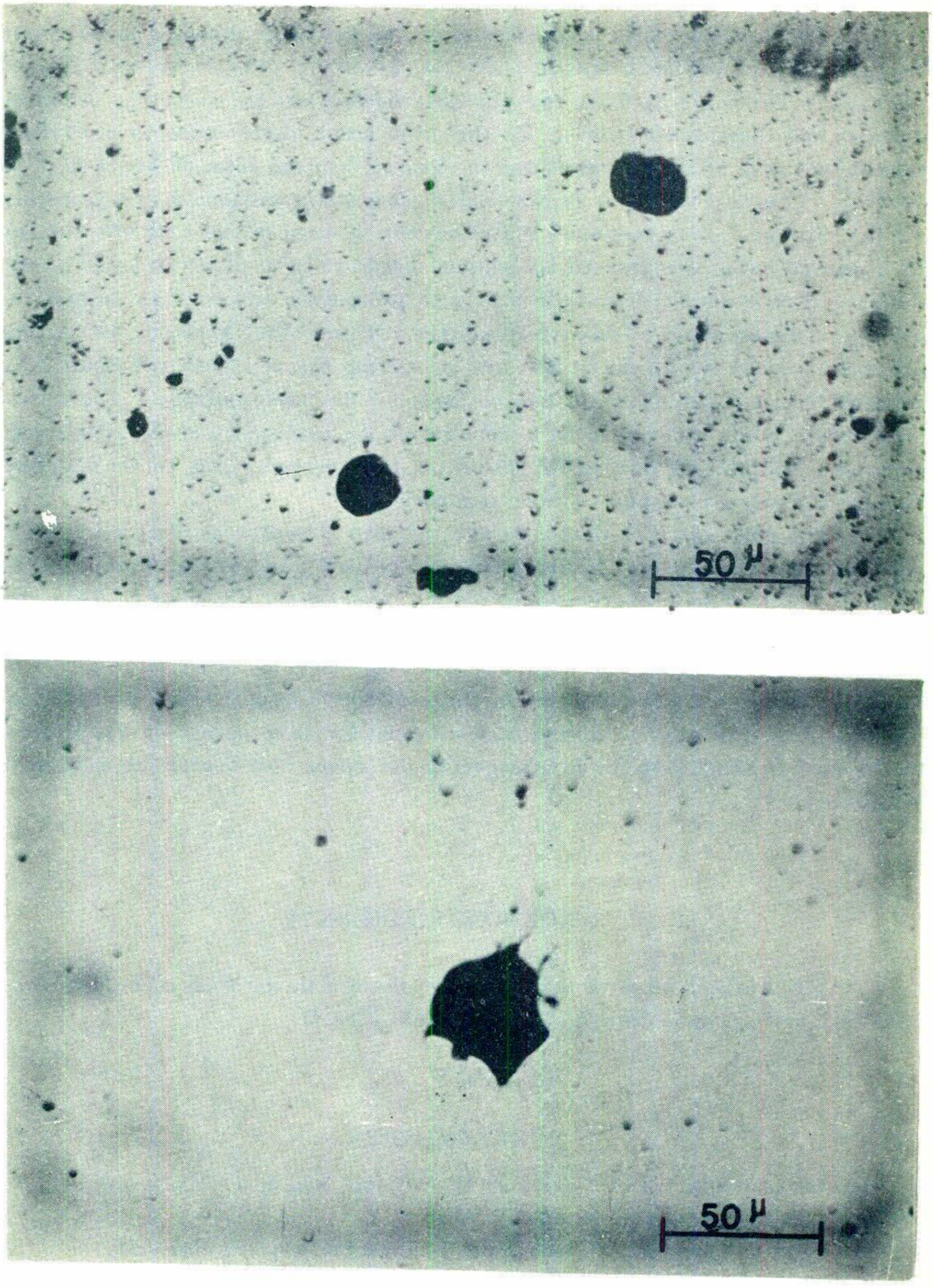

Fig. 1. **Photographs of the holes produced on copper cathodes** of 60 and 20 $\mu gr/cm^2$ respectively. The contrast in sizes and shapes is clear.

The erosion of the cathode due to the spark is assumed to be caused by sputtering of cathode material by the positive ions arriving with the streamer. There are at least two possible mechanisms for sputtering: momentum transfer and thermal ejection[4]. On the other hand, there seems to be evidence that in the case of copper, material is extracted in the form of small metallic spheres[5]. On the whole, it is not really clear what mechanism is responsible for the erosion. It is proposed that a careful control of the cathode, as may be obtained using the present technique, could help to clear up some of the doubts. For example, from hole size and geometry one can calculate the number of atoms removed from the cathode. On the other hand, by measuring the total current during the pulse, and assuming the streamer and sputtering mechanisms, a crude estimate can be made of the same number. The difference between the two would be a measure of the inadequacy of the assumptions. One such calculation was made; the latter number turns out to be six times smaller than that from pure volume removal.

The most obvious disadvantage of this detector is that the cathode material soon disappears, limiting its use to low numbers of total counts. Also, in contrast with photographic plates, it does not distinguish different types of particles. As with other gaseous detectors there is need for a window to maintain the operating pressure, and a large number of wires to cover the region of interest. For the moment, these disadvantages seem to outweigh the advantages of easy scanning, and no need for developing plates. However the method is promising for investigating the spark and sputtering mechanisms mentioned.

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RESUMEN

Se desarrolló un detector de chispa con el cátodo consistente de una película metálica delgada para posible uso en espectrógrafos magnéticos. La chispa erosiona el material del cátodo, dejando un agujero bien visible, y facilitando la lectura al microscopio. Se determinaron los espesores óptimos de operación, para películas de cobre y de oro, y se llevó a cabo un estudio de tamaños y formas de las cavidades. Se hace notar que esta técnica puede ser útil en el estudio de los mecanismos de la chispa y de la erosión del cátodo.