

SILVER FROM USED X-RAY FILMS: AN INCREASINGLY CRITICAL RESOURCE¹

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At a time when world supplies of silver are diminishing and the demand for it is growing, the processing of medical X-ray films is a source from which considerable quantities of the metal can be recovered.

An incalculable fortune literally goes "down the drain" in the silver that is washed off X-ray films in radiology services throughout the Americas. In film processing, an average of about 50 per cent of the silver remains in the emulsion; the rest comes off as the image is revealed. When no effort is made to recover this precious metal from the developer solution, the particles are carried along through the plumbing to the rivers and the seas, forever lost. More often than not, a clogged drainpipe in a radiology service is "worth its weight in silver."

Hard facts are difficult to come by because of the speculation and hoarding associated with silver, but it is reasonable to say that this negligence is going on at a time when mines are able to furnish but 40 per cent of the world's needs. The remaining 60 per cent must be drawn from existing supplies—national stockpiles, coinage no longer in use, salvaged industrial waste.

For more than a decade much of the deficit had been met from U.S. Treasury reserves, but this source, down from 1,800

million troy ounces in 1960 to only 180 million at the end of 1976, is likely to be discontinued. To make matters worse, exports of Russian silver to the noncommunist world have been banned since 1970 (1). Coins made of silver, in turn, are being increasingly withheld by collectors as the premium on them rises, so that this source, too, has been nearly cut off. At the same time, despite advances in technology that have temporarily improved yields, existing mines are gradually being depleted, and it is believed that few if any of the earth's richest lodes remain to be discovered. Meanwhile, the gap widens between supply and demand.

Silver—used, among other purposes, for photography, as a conductor of electricity, as an alloy for joining nonferrous metals, as a catalyst in nuclear reactor control rods—is in many instances virtually irreplaceable. Even though substitutes are actively being sought, no real relief is expected for another five years at the earliest (1).

In the face of this constellation of difficulties that has taken shape in the late 1970's, the recovery of silver from photographic and X-ray films assumes critical new importance.

From X-ray film alone, the rate of waste could easily correspond to half or more of a country's annual quota contribution for membership in the Pan American Health

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Organization. This, at a time when acute shortages of funds stand in the way of extending minimum health services and safe water supplies to the people of the Americas who so urgently need them—and of progress in so many other specific areas as well.

If an average of 100 X-rays—not a high figure for a busy 300-bed hospital—are taken in a day, the yield in silver would be 820 troy ounces a year. At a market value of US\$4.60⁴ per ounce, this translates into \$3,772. An average of more than double this amount, \$10,303, factors out from the \$1.7 million that was actually garnered in 1975 by the 165 hospitals under the U.S. Veterans Administration, which has a program for the recovery of silver from X-ray films. Middle and South America have approximately 14,000 hospitals of 300 beds or more; hence, by rough calculation, they could realize at the very least \$50 million—and perhaps more than double that amount—from the silver that is currently being let go to waste.

Several simple measures are recommended in connection with the conservation of silver. These include: recovery of the metal from developer solutions using techniques that ensure the maximum yield (approximately 98 per cent); repeated reuse of the same solution; and revision of policies regarding the retirement of stored X-rays with a view to reducing the volume of film, and thus of silver, currently being kept out of circulation.

Recovery from the Developer Solution: Two Procedures

Photographic and X-ray film consists basically of a sheet of transparent acetate

which has been thinly coated with a sensitized, silver-bearing gelatin—the emulsion. Subjected to the developing process, the film's silver halides are reduced to a soluble compound. The developer solution, or fixing bath, washes them off. If the exposure to light has not been too great, as much as 80 per cent of the silver-laden coating may be removed in this way.

X-ray films are an especially important source of silver because of their large size (often 14 x 17 inches) and the fact that they have a double emulsion, both sides of the acetate being coated. It is estimated that in 21 plates measuring 14 x 17 inches (a surface area of 4,998 square inches) the manufacturer uses a full troy ounce of silver (2).

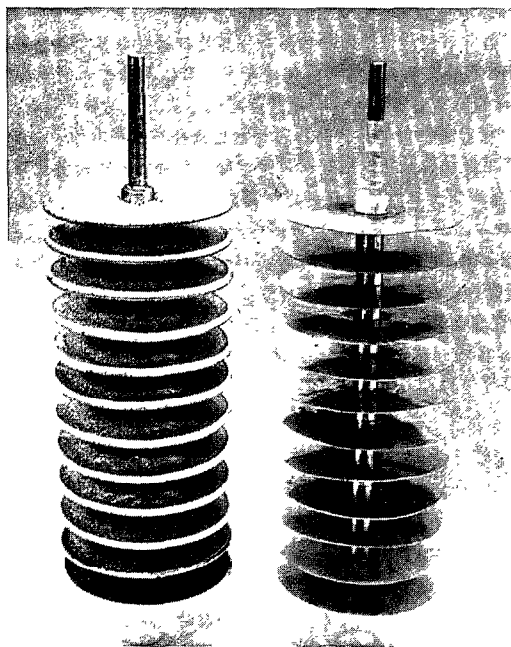
Removal of the metal from the fixing bath is desirable not only in order to recover it for the reasons given above but also because it improves the developing process *per se*: it reduces chemical fog on the film, cuts down on the time required for processing, and, with some methods at least, saves on the cost of the developer solution, which then can be reused a number of times.

Two principal techniques are available for recovering silver from the developer solution: electrolytic plating and metallic replacement. Chemical precipitation and other methods are also possible, although they are not as widely used. While commercial firms can be contracted to do the job, the systems can also be mounted and run by the hospital or radiological service itself.

In *electrolytic plating* the silver is removed by passing an electric current between two electrodes that have been suspended in the solution. The metal gradually builds up on one of them, the cathode, which is fitted with a series of 12 stainless steel discs placed a little more than an inch apart. When the silver plating on the discs has become about half an inch thick, the entire cathode-and-disc assembly is removed so that the metal can be recovered. It is more than 99 per cent fine.

³Calculation based on an estimated daily volume of 25 X-rays multiplied by the number of radiology services in the country and then compared with its quota assessment.

⁴Average price over the period 1975-1976 (1).



In the electrolytic plating process, silver accumulates on a cathode-and-disc assembly (left). When the silver plating is about half an inch thick, the assembly is removed and the precious metal is stripped from the discs.

With *metallic replacement* the dissolved silver reacts with a solid metal, such as zinc, which has been introduced into the fixing bath. Over a 24-hour period, the more active metal, zinc, goes into solution as an ion, while the less active metal, silver, becomes solid. About 12 ounces of zinc dust can precipitate all the silver in a 15-gallon fixing tank within the span of time mentioned. A sludge of metallic silver plus zinc and other residues will have settled at the bottom. The liquid from the developer solution is then decanted and the remaining sludge is allowed to dry so that it can be packaged and sold.

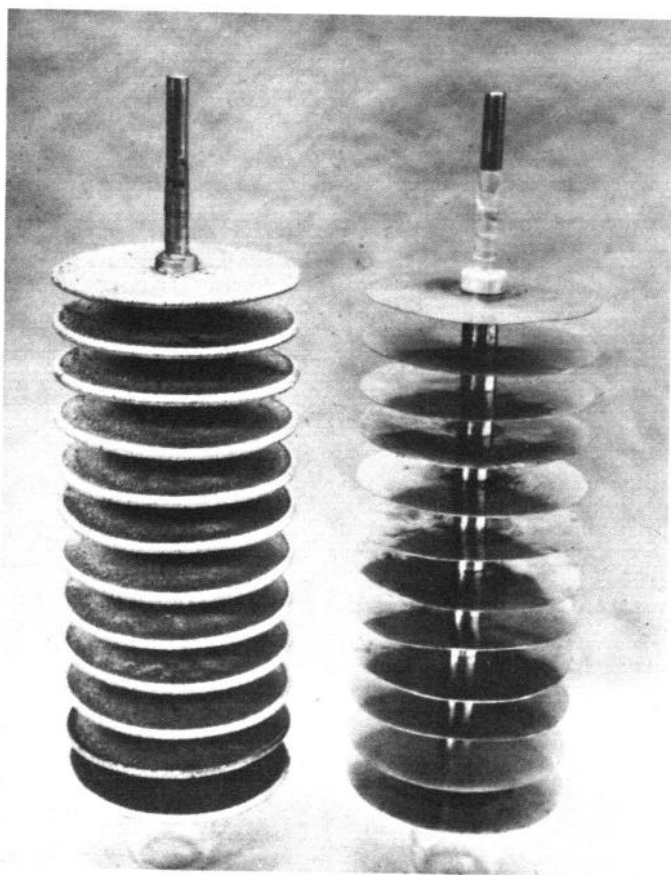
While the electrolytic system provides ready silver of maximum purity and can be economical in cost-benefit terms, it has the disadvantages that it is relatively expensive to install and that it needs to be monitored carefully. Hence it is best suited for

radiology services that have a large volume of films to process. Metallic replacement, on the other hand, is inexpensive to set up, requires little attention, and can be run manually, without electricity. However, the fixing bath cannot be used again, and shipping of the sludge presents problems, including the cost of handling 50 per cent of the weight which is not silver. Still, both methods offer returns many times more valuable than the cost of their installation and operation.

A Program for the Countries

The Pan American Health and Education Foundation, a nonprofit institution working in concert with the Pan American Health Organization on the advancement of its fundamental objectives, has established a program to help hospitals put into practice either of the two procedures just described. PAHEF, on the basis of a prior agreement between PAHO and the respective Government, undertakes to work directly with the hospital and provide the following:

- Supplies and equipment necessary for the recovery process;
- Technical personnel to carry out the recovery procedures;
- Transportation of waste materials, as necessary, to an appropriate plant for processing of the residues;
- Arrangements for selling the elements recovered and placing the net proceeds, after deduction of operating costs, in a U.S. dollar trust fund available to the individual hospital or hospital system for such purposes as training or the purchase of supplies and equipment;
- Periodic financial statements on income from the sale of recovered elements, details of operational costs, and net amount deposited in the trust fund;
- Arrangements, upon request from the hospital, to disburse from the trust fund



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amounts needed for educational activities or the purchase of supplies or equipment; and

- Assistance in any other activities as may be mutually agreed.

The hospital, for its part, provides such personnel, space, equipment, supplies, local expenses, and other facilities or services as may be set forth in its agreement with PAHEF.

A Silver-Conscious Approach to Administration

Hospitals and radiology services can calculate fairly closely how much silver they should be able to recover by looking at the volume of film that they purchase. It can be estimated that 10,000 plates (14 x 17 inches) of medical X-ray film will yield from 150 to 300 troy ounces through recovery procedures applied to the developer solution (3). In 1975-1976 prices, this represents a value of from US\$690 to US\$1,350.

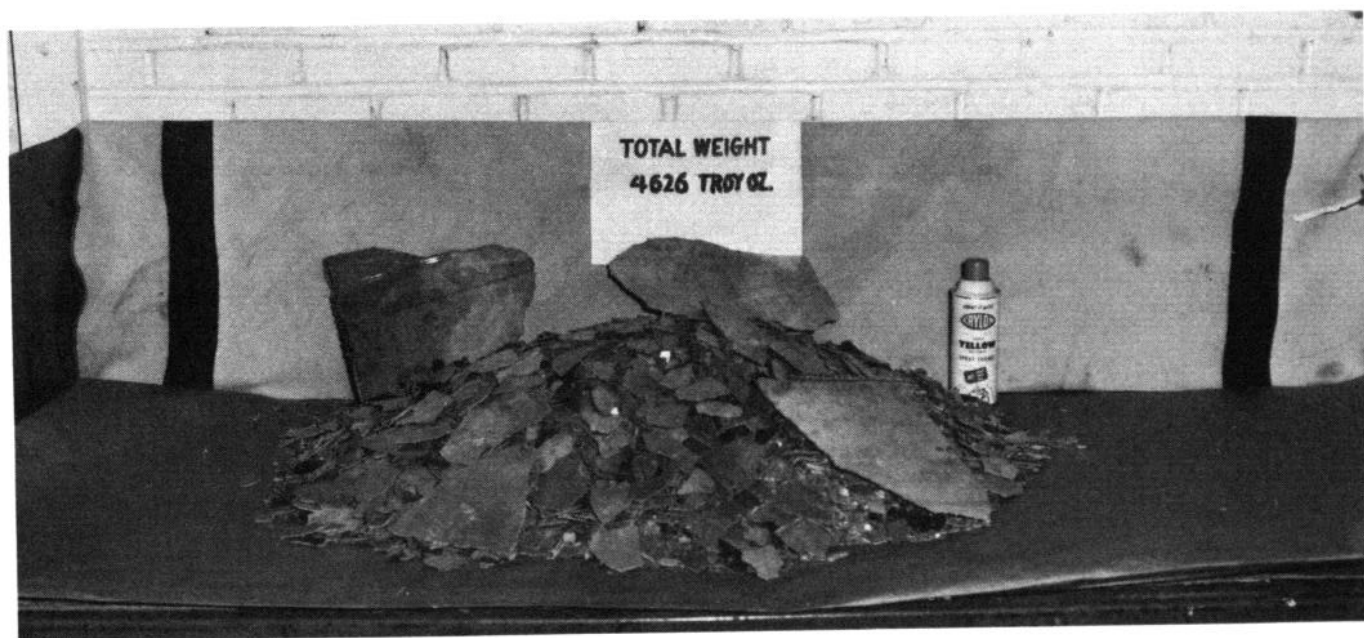
But there is more to the picture yet. These same 10,000 plates originally contained, it shall be guessed, 476 troy ounces of silver—a total value of \$2,187. The rest of the metal remains on the film. This resource is another matter that deserves consideration.

In the past, exposed films have been kept on file indiscriminately for very long periods. More recently, however, policies have been developed that permit the recycling of those films that have no diagnostic value—that is, those revealing no change in a patient over a specified time. Such an approach liberates valuable storage space, reduces clerical work, and, to the point here, makes it possible to recover the remaining silver from the film.

All these factors should be considered in the formulation of hospital administration policy.

Conclusion

Evidently, the small investment that a hospital or radiological service must make in order to recover the silver from its X-ray films is paid back manyfold. The returns can be measured as direct income which can be used to purchase essential supplies and equipment, as money not wasted when people are in urgent need of minimum health services, as savings to the environment, and perhaps most important, as a step in the direction toward meeting the growing demand for silver in the world.



A hospital in the United States of America collected 4,626 troy ounces of silver within a period of 30 days—equivalent in 1975-1976 prices to \$21,279.60.