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Thermoplastic Film Seal for Plutonium Storage Cans

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Abstract

This Report describes the results of task JD-5 (E-162). The objective of this task is to develop a new seal method for plutonium storage cans, which is to reduce the exposure of inspectors and operators on the seal activity used by thermoplastic film.

Sealing material that meets the sealing conditions and applicability of seal was selected. A design of the special pattern was examined.

1. Introduction

The current sealing method for a storage can containing nuclear material is to cover the can with a PVC bag and then to apply a wire seal. Owing to the higher order of plutonium, operators are liable to be exposed during the storage operation and auxiliary work involving inspections, and inspectors during the seal activity of inspection. In view of this danger, this seal was designed to reduce the exposure of inspectors and operators, and somplify seal application. Sealing material, thermoplastic film was selected. This film is printed a design of the special pattern. Two sheets of such films are folded together, and a unique pattern can be obtained due to the film distortion at the time of contraction. This film seal was developed by taking full advantage of the fact that this pattern cannot be reproduced and can be verified easily in a short time.

2. Purpose

The IAEA safeguards approach to any particular facility is based on nuclear material accountancy, complemented by containment and surveillance measures.

For sealing plutonium storage SUS cans, memory film (generally called heat shrinkable film) was chosen as a sealing material, and the development of a sealing method excellent in enclosing ability, uniqueness, and resistance was requested for minimizing exposure of inspectors to radiation, simplifying sealing operation and easily verification in a short time.

3. Description of Development

3-1 Requirement of Properties and Qualities

The above mentioned thermoplastic film (also called memory film) is a film which is subjected to elongation process free from thermal fixing in the film making process, and contracts (by 40-60%) when heated (usually, at 40℃ to 120℃). In other words, the film is thermoplastic, i.e. it becomes soft on heating and hardens on cooling.

When the object being sealed is covered with this film and subjected to heating by taking advantage of the above thermoplastic characteristics, contraction occurs along the shape of the object being sealed. In order to remove this film, there is no alternative but to use physical means such as cutting. Based on these characteristics, tests were made for requirements such as seal applicability, uniqueness and ease of handling. From among thermoplastic film are as follows;

① polyethylene film
② polyvinyl-chloride (PVC) film
③ poly-propylene film
④ polyester film
⑤ polystyrene film

A film that meets the following requirements was selected;

① Temperature resistance (about 80℃)
② No deterioration due to radioactive rays
③ Weight resistance (about 15kg)
④ Uniqueness of design pattern
⑤ Superb seal applicability

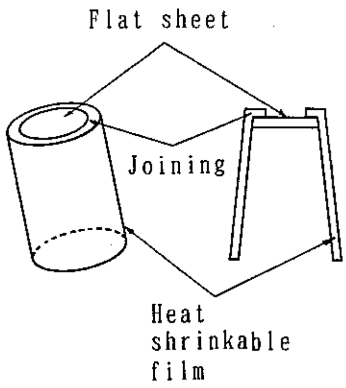
As a result, PVC film was selected as a thermoplastic film that conforms to the above requirements.

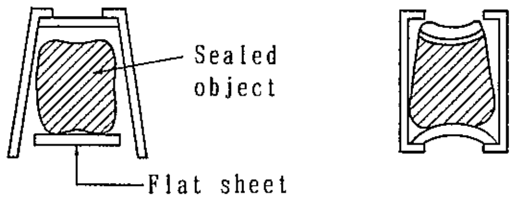
3-2 Types of Seal

The objects of sealing were cylindrical metal cans wrapped up with soft PVC envelopes. For the purpose of study, the following types of seal were taken up as satisfying the above property and quality requirements and capable of covering the whole object as far as possible.

(1) Closed Top Seal Method

In this method, a tube with one end closed with a flat plate made of plastic sheet or special paper and the other end opened as illustrated below was provided beforehand, and sealed by inserting a flat sheet in the open end before shrinkage.

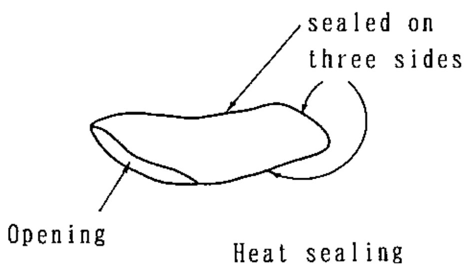


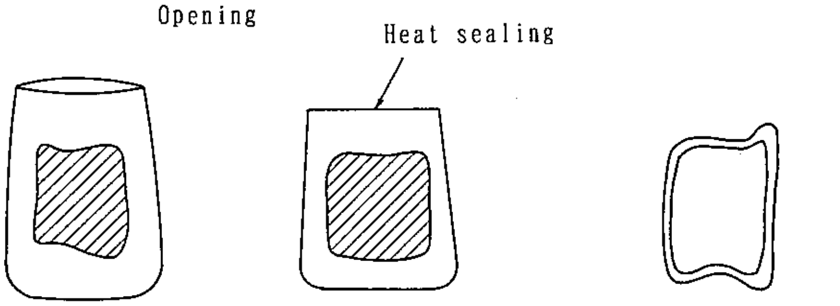


Before shrinkage After shrinkage

(2) Overlap Seal Method

In this method, an envelope with three sides sealed as illustrated below was provided beforehand and sealed at the open side by heat after putting the object in the envelope.





Before shrinkage After shrinkage

(3) Sleeve Wrap Seal Method

In this method, the object was sealed in a tubelar film.

Before shrinkage After shrinkage

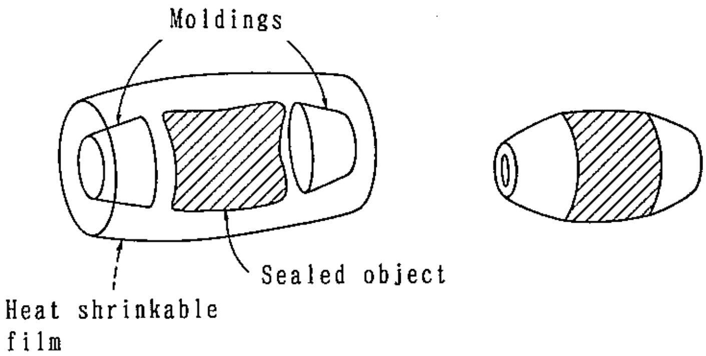
(4) Double Wrap Seal Method

In this method, the object was sealed by the above sleeve wrap method twice in contrary directions.

Before shrinkage After shrinkage

(5) Seal Method with Moldings

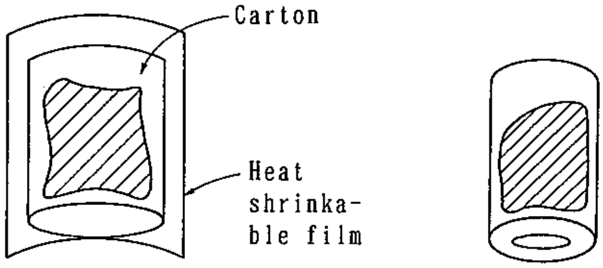
In this Method, moldings substituted the plate sheets of the closed seal method as illustrated below.



Before shrinkage After shrinkage

(6) Seal Method with Cartons

In this Method, object is put in a flammable carton and sealed.



Before shrinkage After shrinkage

The preliminary tests of the above seal methods indicated that the direct sealing with heat shrinkable film could not obtain a beautiful shape because the objects were wrapped with soft PVC envelopes and air was remaining in the envelopes, and that the check of imitation was difficult because the sealed packages had a possibility of being exposed to 60℃ to 80℃ subjected perpetual shrinkage and the seal changed with time. Thus the improvement is being studied on the above methods and others including printing on the packages, and use of tack paper, etc.

3-3 Sealing Jig

The following jig was studied as satisfying the requirements stated below.

① Anybody can use easily.
② The jig does not require a large space.
③ The jig does not contaminate the air in the room.
④ The jig can seal in a short time.
⑤ The jig satisfies given sealing functions.
⑥ The jig is an energy saving type.

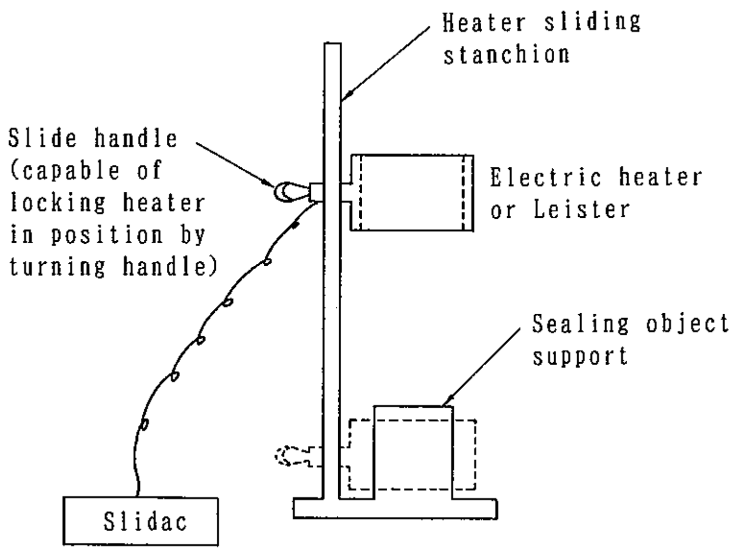


Fig. 1 Sealing Jig

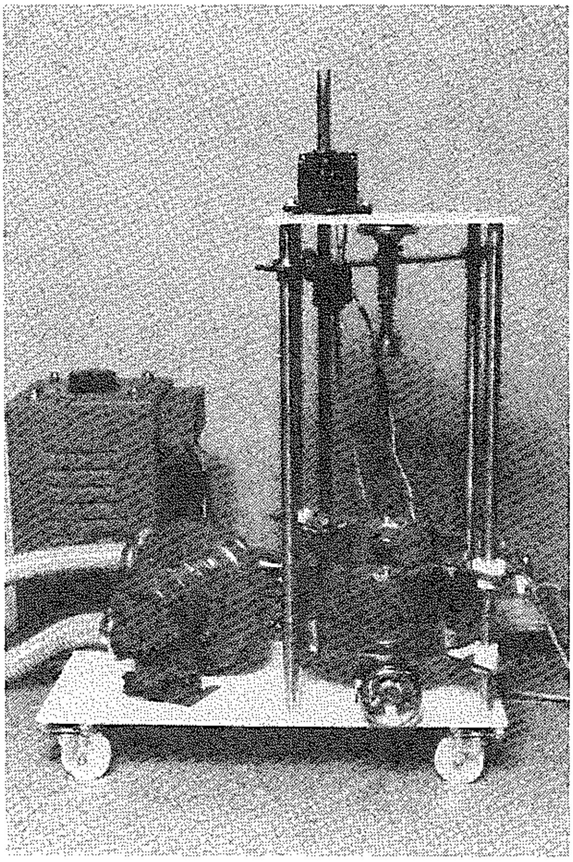


Photo. 1 Sealing Jig

3-4 Determination of Diementions and Shape

Film seal material being sealed is an indeterminate cylindrical type and a shape capable of entirely enclosing the material was selected.

The following are the evaluations of various shapes.

(1) Closed Top Seal Method

In this method, a top plate (plastic, compound fiber, etc.) was bonded to one end of the heat shrink film seal, and a bottom plate was inserted to the other end, and then the entire film was heated.

Since the SUS can was enclosed by a flexible PVC bag and heat-sealed, the sealed material became instable because of residual air after shrinkage.

Whereby the finished shape was quite unacceptable

(2) Overlap Seal Method

In this method, the can was entirely enclosed by film and the film was heat shrinked. Since partical heat sealing was required in enclosing, a jig was required, and the shape after heat shrink was instable. Thus this method had problems in the easiness of sealing and in the enclosing ability (finished shape).

(3) Sleeve Wrap Seal Method

In this method, the can was put in a sleeve type heat shrinkable film and then heated to shrink the film. After shrunk, the can was exposed out of the opening of the sleeve and could not be sealed entirely.

(4) Double Wrap Seal Method

Heat shrink film has instable behavior after heat shrinking, and the behavior is unreproducible.

This method intended to record deformation after heat shrink by printing a pattern or letters on the film by utilizing the unreproducibility. Further this method employed two shrink films for enhancing the effect.

This method had probems in finishing and wrapping when two films were superimposed and it was considered to use this method with other method.

(5) Other Methods

① Sealing with Moldings

This method combined the sleeve wrap seal method and moldings. The intention was to gather residual air in the moldings and improve the finished shape. AS the finish of the sleeve opening was not determinate, the effect of double seal was obtained by giving a certain shape to the moldings.

② Casing and Shrink Method

The can was put in a rigid casing, and the casing was put in the shrink film sleeve and heated.

This method yielded a stable finishing.

The methods (5) showed the best finishing.

After considering the method satisfying the requirements, the following method was established by improving the methods (5). (Refer to Fig.1-1 and 1-4)

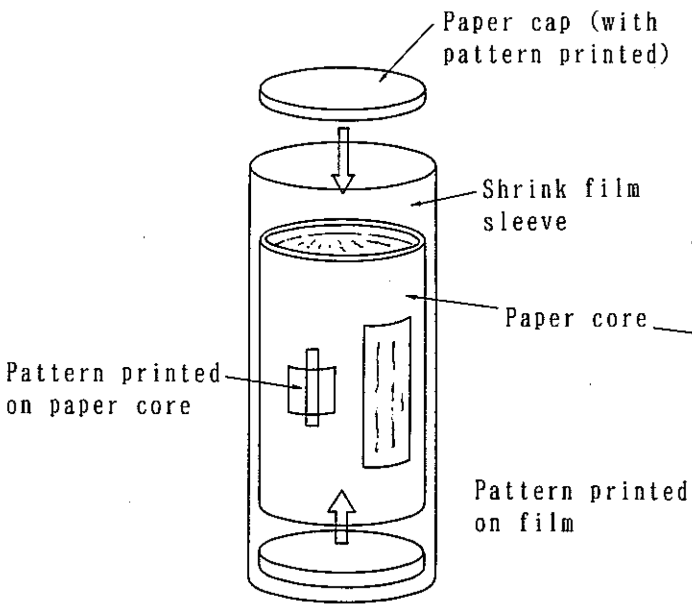


Fig. 1-2

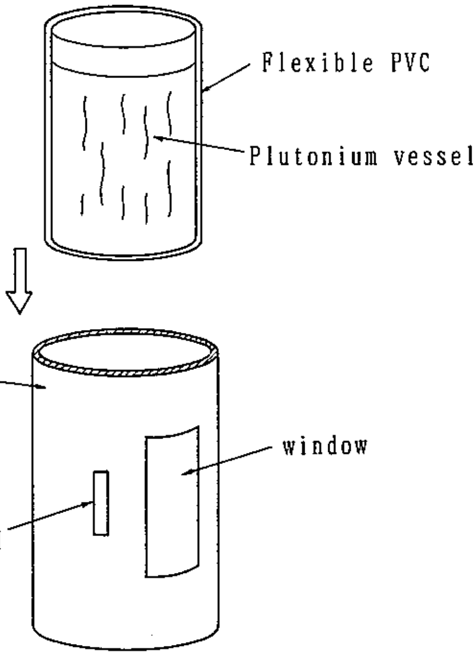


Fig. 1-1

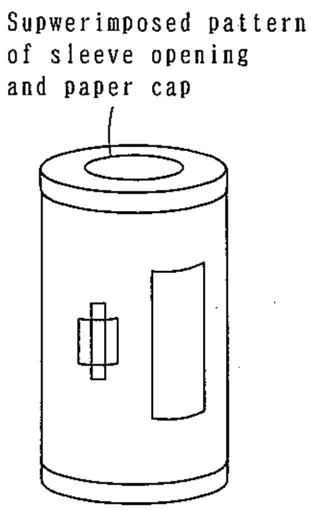


Fig. 1-3

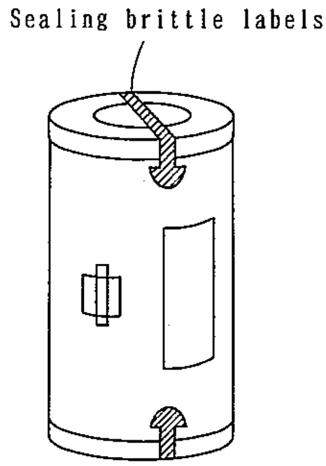


Fig. 1-4

Basic Specifications of Establish Method:

(a) The can is enclosed in the paper core and the core is closed with the top and bottom caps. The package is enclosed with the sleeve wrap shrink film and sealed with brittle labels at the top and the bottom.

(b) A Pattern is printed on the paper core. Also a pattern is printed on the shrink film. The shrink film of high transverse contraction (60%) is employed and the diameter of the shrink film is to be larger than the paper core diameter to yield a large strain by shrinking. Accordingly, deformation is produced at the superimposed patterns and gives uniquness.

(c) Brittle carbon-print paper is stuck to the paper core.

(d) The film is heat shrinked.

(e) Concentric circles are printed on the paper cap and a liner pattern is printed on the end of the shrink film. After heat shrink, uniqueness is yielded by deformed superimposed patterns due to the heat shrink of the sleeve.

(f) Brittle sealing labels are stucked to the top and the bottom.

The paper core and the paper caps can be burned, the problem of waste treatment is eliminated. By making the paper core slightly larger, SUS cans of various sizes can be packed in the paper cores. Whereby the dimentions are standardized and the storage can be standardized.

3-5 Results of Evaluation Tests of Seal Film Sealing

(1) Enclosing Test (Finishing)

As the can is enclosed by a flexible PVC bag, the shape is indeterminate. The developed sealing method showed stable enclosing ability because of a rigid casing enclosing the can and heat shrink sealing of the casing by heat shrink film.

The heat shrink film became plastic by heating, shranks snugly in conformity with the paper core, and hardened along the outline of the paper core by cooling. The seal film was not changed chemically and just softened and melted physically without changing physical properties (only the thickness was slightly increased), meeting the enclosing ability requirement.

The cooled sealing film snugly to the paper core showing excellent enclosing ability and sealing ability.

(2) Uniquness Test

Since the sealing film snugly fitted to the paper core by heat shrinking and hardening by cooling, the film could not be replaced unless it was torn off and the torn off film could not be resealed. Thus the developed seal could not be imitated. Further in the debeloped sealing method, patterns were printed on the paper core, paper cap, and shrink film, and the superimposed patterns are deformed by thermal strain at heat shrinking. The deformed superimposed patterns are indeterminate and can not be reproduced by removing the existing film and sealing again with a shrink film of the same specifications. Also the sealing labels stuck to the top and the bottom were brittle and could not be reused after breaking once. Thus the sealing method was proved unique.

(3) Versatility Test

The material being sealed in SUS can is enclosed with a flexible PVC bag, and the package geometry is indeterminate. Also the size of SUS cans is supposedly varying.

Since the developed sealing method employs a paper core, for housing the SUS can, cans of various sizes can be sealed by determining the size of the paper core according to the maximum size of the SUS can or determining the size capable of accommodating several sizes of the can. Whereby a standardized geometry is obtained after sealing, enabling the standardization of storage and transportation.

(4) Test fot Easiness of Sealing Operation

The developed sealing method enabled stable operation by maintaining the once determined heat shrinking conditions because the paper core of the standardized geometry was used.

Further stability of operation was yielded by the semiautomatic heat shrink jig prototype designed and fabricated along with the development of the sealing method.

(Sealing can be performed in about one minute 30 seconds to about two seconds per one packade.)

(5) Seal Opening Test

The opening of sealing was very satisfactory because the sealing was opened only by pulling the sealing film along the perforated line.

Since the sealing was opened by tearing the sealing film, the sealing could not be restored, proving that the sealing could not be imitated.

3-6 Final Applicarion

It is not desirable to apply a thermoplastic film directly to the plutonium SUS can covered with PVC. The plutonium SUS can is put into a container made of paper. A thermoplastic film printed with a design is wrapped around the paper container and heated with a drier to cause contraction. Then a thermaoplastic film printed with another design is wrapped around the container, and heated with a drier to cause contraction after alignment in the proper position. By so doing a dual design can be prepared which has a unique and random pattern.

In the initial exercise, a design was printed directry on the surface of a paper-made container and then a thermoplastic film printed with a unique design was attached to it. In view of the fact the design on the paper container is constant and reproducible when the film is installed, and that the paper-container cannot be reused many times, efforts were made to develop a unique pattern by folding two sheets of design-printed thermoplastic films without applying a design to the paper container.

4. Review of a Pattern Design

Review 1

After putting a SUS can into the paper container, two sheets of thermoplastic films are applied. Each of these thermoplastic films are printed with the definite design. When two designs are folded together, a random and unique pattern arises from the distortion due to contraction. As to a design to be printed on this film, the design of a wave-form has been devised. When two designs of wave-forms are folded, a unique un-reproducible pattern appears. This pattern is photographed and checked its completeness against the seal pattern at the time of seal verification. (See Photo 2.)

However, since this method required much time to check the seal pattern against the photo and made varification difficult, another design was devised.

Review 2

In order to solve the problems raised in Review 1, a study was made of a design which can be judged easily in short time. As a result, an intersection point merhod was adopted. As to a design for an intersection point method, two types were devised: one has thin lines printed on a sheet of film at intervals provided at random, each line being numbered, and the other has thick lines printed in the same manner with each line numbered. Inspectors record the respective numbers against the intersected lines at the time of verification. (See Figure 2)

In the case of another intersection point method, a design of on inverted triangle (▽) is printed on a sheet of film, and coordinates with slanted lines are printed on another sheet of film. A record is made of the figure at a place where the end of an inverted triangle shape formed by folding two sheets of films coincides with a slanted line. As in the above method, inspectors check the recorded figure against the intersection point at the time of verification. (See Figure 3.)

In addition, a study was also made of a design using bar codes. In this case, the lines composed by folding two sheets of films having lines of random thickness are recorded with a bar-coder (bar code recorder), through electronics conversion of line into a numerical figure. At the time of verification, the figures read and recorded by a bar-coder on the basis of the composite lines are checked against the read figure. This has the advantage that verification can be carried out in a short time. At present, however, this study has ended only at the stage of development of a design, because of the difficulty in obtaining a bar-coder for random reading.

5. Conclusion

As a thermoplastic film, thermoplastic lateral single axle PVC was adopted. By adopting a design based on the coordinates method to be printed on the film, it became possible to check the integrity of a seal easily and in a short time. Moreover, film application was easy and thermoplastic characteristics were found satisfactory.

However, currently new C/S approach has been applied at particular facility, which are VACOSS seal combination with MIVS camera, so called dual C/S system, that this method is meaningless, because new C/S approach dose not require reverification of the plutonium cans.

6. Remarks

At the request of IAEA, a sample of a thermoplastic film having the above mentioned design was delivered to IAEA.

Reference

1) Mckelyer, Strome, Mod, Plastics. Vo 7, 34, No. 107, (1957)

2) Plastic Film Research Society. Fabrication and Application of Plastics Film, (1978)

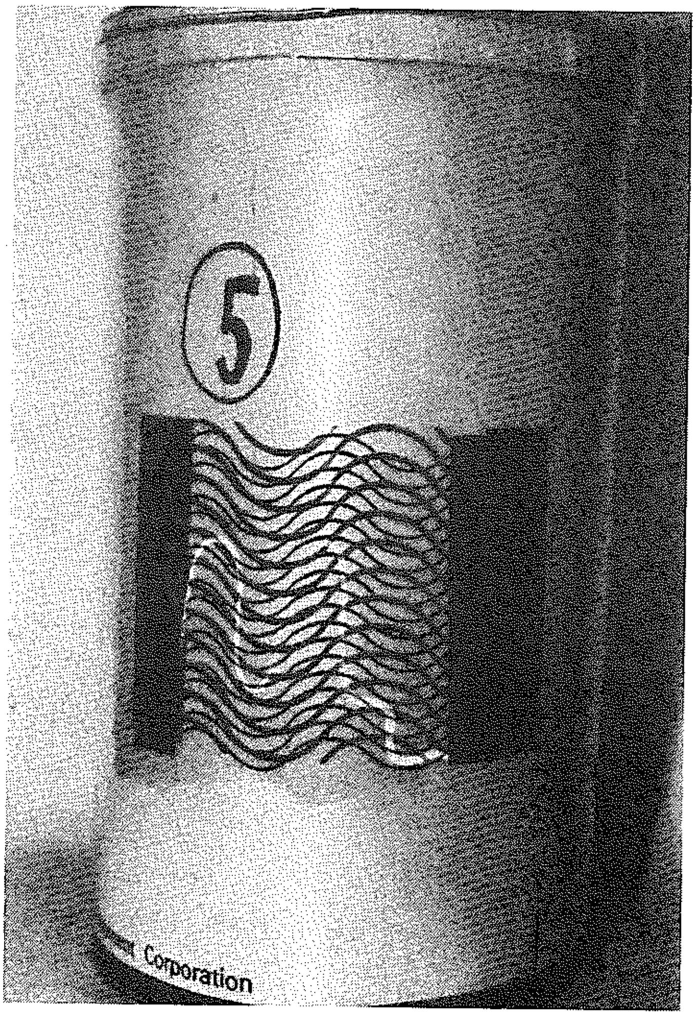
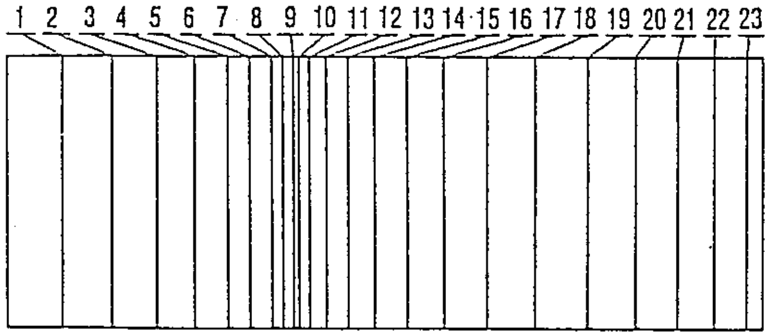
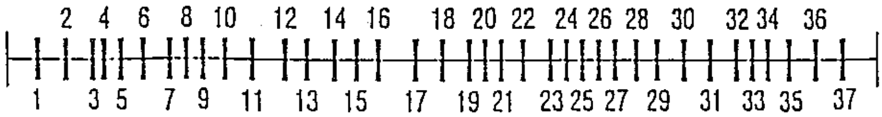


Photo. 2 Thermoplastic film having a folded waveform design

Film A



Film B



(I)

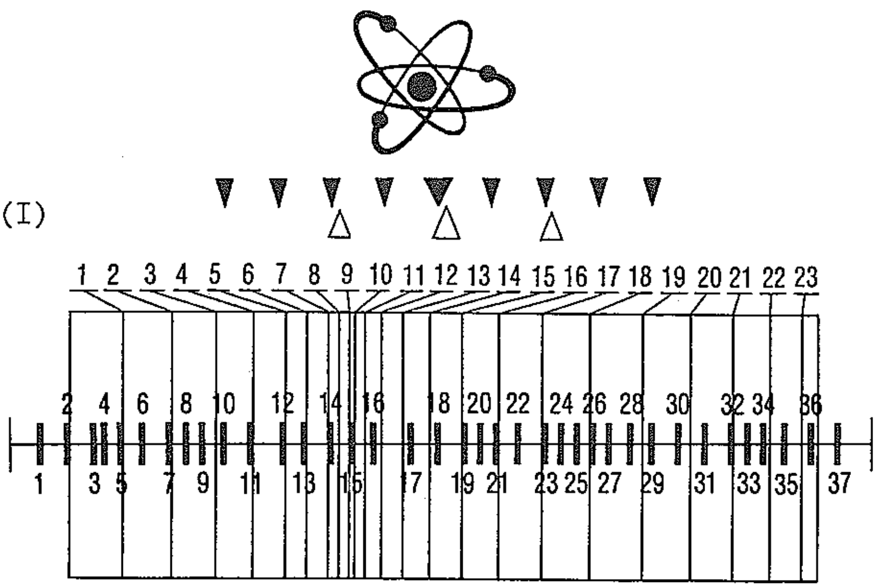
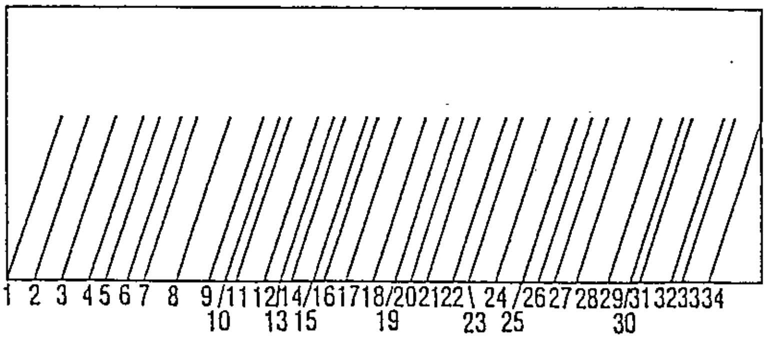
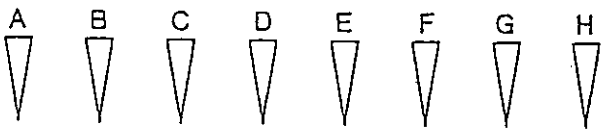


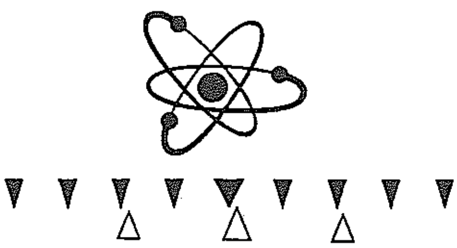
Figure 2. Unique pattern (I) by intersection point method
(read the coordinates at an intersection point by folding Film A and Film B.)

Film C



Film D





(II)

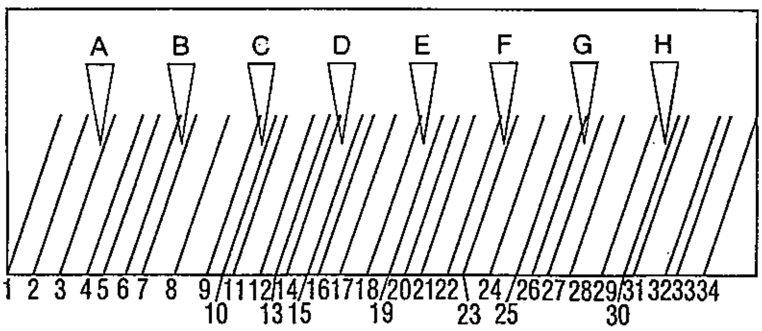


Figure 3. Unique pattern (II) by intersection point method
(read the coordinates at an intersection point by folding Film C and Film D.)