AN EXAMINATION OF CASE SEALING IN THE CENTRAL PACKING AREA OF WESTERN ELECTRIC'S INDIANAPOLIS WORKS

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ABSTRACT

AN EXAMINATION OF CASE SEALING
IN THE CENTRAL PACKING AREA OF
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In this thesis, the author examines case sealing in the central packing situation at the Indianapolis Works of Western Electric Company, Incorporated, as it functioned between June and September, 1963.

Case sealing methods are considered in light of area needs as well as those of related systems. Annual costs and qualitative factors showed a glue sealer to be most advantageous provided consistently good results could be obtained with a wide variety of liners and coatings.

Glueing variables and their interactions are discussed and characteristics of common case sealing adhesives are compared. A resin emulsion is shown to be theoretically best for the central packing situation.

Production and experimental tests were run using resin emulsion and borated dextrin adhesives. The resin gave consistently good results even with difficult liner finishes and proved far superior to the dextrin on almost all counts. Aside from adhesive type, liner orientation and finish proved to be the most significant variables.

A presettable, but not random, glue sealer is recommended, utilizing a pressurized glue system and a resin emulsion adhesive.

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Richard James Frank

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His warmest thanks are given to Western Electric for the opportunity to do the study on which this thesis is based. Each of the men and women in department 845 contributed in one way or another, but special thanks are extended to Bruce Robertson, whose unquenchable humor and encouragement made many an otherwise frustrating day, rewarding.

Dick Asbury must, in a like manner, be singled out. His constant "Show me," attitude gave assurance against the acceptance of unwarranted conclusions. It did not, however, stop him from granting full cooperation, without which valuable data could not have been gathered nor necessary experimental changes introduced. His final acceptance and friendship were reward in themselves.

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INTRODUCTION

Method

In this thesis the author attempts to analyze existing and potential sealing methods for the central packing operations of Western Electric Company, Inc.'s Indianapolis Works.

The bulk of this study is based on the author's experience during the period from June 15 to September 25, 1963 when he was employed by Western Electric as a packaging engineer.

His major project was to make recommendations in regard to sealing methods useful to the Indianapolis Works; he was given a free rein and complete cooperation. During this period, maintenance, purchasing and inspection records were reviewed concerning all existing sealing methods. Operational and economic data were collected, several experimental changes were introduced, and theoretical research was done at that time. Technical representatives of National Starch and Chemical Company and Inland Container were conferred with as well as men representing various machinery companies.

The theoretical part of this work has been updated to utilize the wealth of recent literature on some aspects of this study. The author was pleased to find most of his original findings reinforced by subsequent articles and a couple of hazy points cleared up.

The author has attempted to write this thesis from a broader perspective than the original study while still adequately covering functional considerations.

Due to the disparity in times of data collection and writing a reconciliation is necessary. For purposes of this writing, 1963 conditions will be assumed in existence, both in the corporation and its operating environment.

Background

Western Electric joined the Bell System in 1882 and has two purposes from AT and T's point of view: (1) It furnishes the Bell System with the equipment it needs and (2) It makes a profit. The Indianapolis Works makes almost all the telephone sets used throughout this country and many used elsewhere along with piece parts and apparatus for these units. (This amounts to about 8,000,000 telephone sets each year.)

Western Electric furnishes not only AT and T, but IT and T, their Canadian counterpart, and independent companies such as Graybar and Northern Electric with much of their equipment.

Since the war, much time and effort has been devoted to government endeavors, including the DEW line and several missile projects. The rapid technological pace is emphasized by the fact that two thirds of their present products have been introduced or significantly modified since 1950. The Indianapolis Works had many new and potential

products at various stages of development at the time of this study. Several were moderately revolutionary and one was extremely delicate.

The Indianapolis Works is one of twenty-two manufacturing locations which, along with thirty-seven service divisions and three subsidiaries, make up Western Electric. This location employs about 7,200 blue collar workers and 200 engineers.

About four billion dollars of the 16.5 billion dollars industry spends each year on packaging is for industrial products.[1] As in consumer packaging, the package may be used as a merchandising tool and to project the company's image. Its primary uses, however, are to protect, contain and identify the product.

Packaging has been mostly in chip-board cartons and corrugated. They are just getting into some transparent packaging, causing loose filled shipping cases of the bulk apparatus and piece parts so packed. They've been hand-sealing some polyethylene bags and recently acquired a pouch making machine (Mira-Pak) that will package several parts at almost sixty sets per minute in mylar. Another significant source of hard to seal cases is the Sundstrand which packages small sets of piece parts or apparatus in heat sealed poly-coated kraft.

They were planning their first expanded polyethylene pack toward the end of the summer. Considering some of the items their

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[1] Melvin Mandell, "New Ways of Packaging for Profit: Part II," Dun's Review and Modern Industry, 52-55, November, 1959.

research departments are working on, this will be used much more in the future.

Western Electric is in a unique position in that it has to worry less about merchandising than even most industrial suppliers. By the time the housewife sees the package she has already made the decision to get the extra phone.

Management is beginning to realize, however, that graphics and a good looking package can influence the warehouseman as well as the housewife (not necessarily the same ones). Some two color corrugated and printed bleached kraft are used due to the small increase in price over regular cartons, even with the minimal direct advertising value. Even if they put the two color printing on the bleached kraft it would only be 2% or 3% more expensive than plain kraft.[2] Extreme competition in the corrugated industry invites even smaller increments from some suppliers. A new process of printing on the liner before combination is allowing very high quality printing to be done at a more reasonable cost than previously. Even four colors can be run at about the price of three colors on the standard printer-slotter due to the higher speeds obtainable.[3] The Indianapolis Works has not gone to this yet, but may well do so in the future. These do not increase sales directly, but they do show customers and servicemen that the Bell System cares about its products.

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[2] Kendall August, "Industrial Packaging: The Key Word is 'Merchandising'", Dun's Review and Modern Industry, 93+, December, 1964.

[3] Ibid.

As will be shown later, special printing and surface preparation, either now or in the future, could affect sealing under some conditions.

Shipping at the present time is almost exclusively in the United States and Canada. Western Electric's rapid expansion in recent years (twenty-nine of their distributing houses and eight of their manufacturing locations did not exist twenty years ago) and work in international communications dictate that consideration be given the possible exporting of many of their packs in the future.

It must first be emphasized that corrugated containers, though economical, are unsuitable for the export shipping of many items. The danger of water and/or moisture damage is much higher than in domestic shipping. (Moisture damage accounted for only 2% of domestic railroad claims, but 18% of overseas loss and damage claims.)[4] Cases may well collapse because of moisture absorption due to sweating of the hold, condensation of contents, or exposure to the elements in storage, loading or transport. Apart from water damage, generally rougher handling and extensive pilferage may eliminate consideration of corrugated containers for other products of Western Electric.

The use of fibreboard boxes for expensive and delicate products would certainly be false economy. Still, many sets of piece parts and apparatus could be exported in corrugated fairly safely if sealed

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[4] Export Packaging, Published by the Insurance Company of North America, Philadelphia, Pa.

properly. Flaps should be fully sealed with a water resistant adhesive. Water glass (sodium silicate)is outstanding in this respect, but has other disadvantages (cleanup, changeover, etc.). Many resin emulsions are also suitable. For further protection, all seams could be sealed with a water-resistant tape. This would be of necessity a hand operation. Reinforcing strapping or a light wood overpack are also suggested options.[5]

The use of printed sealing tape, instructing cosignees to immediately inspect for loss and/or damage if tape has been disturbed is sometimes wise. Plain tapes, stapling or stitching invite pilferage since opening and reclosing can often be done with no damage to the container and little evidence of tampering.

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[5] Ports of the World (7th edition), Published by the Insurance Company of North America, Philadelphia, Pa.

PERSPECTIVE

Packaging in Perspective

Just how important is packaging? The answer to this depends not only on the measure you use,but also on your source. Using monetary terms, a special report in Business Week stated that twelve to thirteen billion dollars each year is spent on packages and packaging materials with that much again added to bring about conversion to finished packages.[6] Melvin Mandell, in an article for Dun's Review and Modern Industry came up with, as stated earlier, a 16.5 billion dollar total.[7] The variance is primarily caused by inclusion of different factors in the authors' perceptions of "packaging."

Dollar totals are perhaps a poor indication of the true significance of packaging. Inadequate packaging can cause an expensive precision instrument to be worthless. The author's co-workers were asked to design a pack to safely transport an instrument that had proved incapable of being hand carried for further testing in Western Electric's North Carolina Labs. Gross overpackaging or lack of consideration of

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[6] "The Power of Proper Packaging (Special Report), "Business Week, 90-114, February 20, 1965.

[7] Mandell, "Part II, " Op. cit.

related aspects in the name of zeal for protection can, on the other hand, negate the advantages of consideration in the first place and be a needless drain on company assets.

The increased acknowledgement of packaging's importance is illustrated by the 500% increase in packaging activity in the last twenty years according to Stephen M. Barker, director of market development at Continental Can.[8] This realization is in evidence at the Indianapolis Works. It is coupled, however, with frustration and sometimes a bit of resentment by people outside the packing departments. Most do not really understand packaging and are quite willing to give free rein to packaging engineers as long as no complaints are received.

This is further exemplified by some reluctance to rotate packaging engineers. Rotation is commonplace at Western Electric and promotion to supervisory positions is normally predicated on the wider perspectives gained by such exposure. Exculsion from promotion is not implied. Rotation may be requested by the engineer and an obviously underutilized man will surely be groomed for advancement. Still, an engineer genuinely packaging oriented or a blue collar worker satisfied in central packing will rarely be shifted to other work.

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[8] "Power of Positive Packaging," Op. cit.

There are three major divisions of packing at the Indianapolis Works. Two of these output approximately the same volume in terms of final shipping containers (roughly 1,000,000 per year apiece). Telephones are packed in preliminary containers from production lines and are put on a conveyor that takes them to accumulators where they are hand packed in appropriate finals by three men. These final cartons proceed upward to more accumulating conveyors. When a pallet load is ready on a given conveyor a signal is automatically activated on the master control panel. One man watches this panel from astride a fork truck. He controls the course of the cases from that point on and may call the cases on any of these lines through a Standard Knapp glue sealer and then on to be automatically palletized. Only three case sizes are used at this point and the sealer is automated to adjust at the touch of a button on the control panel. This man also keeps the magazine filled with empty pallets and may take loaded pallets off. There is room for a backup of two or three pallets and other men with lift trucks usually take the pallets elsewhere in the merchandise (warehouse) area or directly to loading docks.

The second major area is central packing where a great variety of piece parts and apparatus are packed in preliminary and final containers. These are brought from production areas in trays by lift truck and most cartons are sealed in the area on an Acme Silver Stitcher and sent on an overhead conveyor to the automatic palletizer mentioned previously. A few special orders and bulk packs that cannot be stitched

utilize two strip reinforced tape applied by hand. Coin collectors are also exceptions packaged in full overlap finals utilizing a combination of reinforced tape and staples, all hand applied. Another manufacturing area in Indianapolis (Washington Street) was about to be absorbed in the main location due to an expiring lease. Along with other inherent effects, this was expected to raise the output of central packing by about 25%.

The third major sealing area is the molding room where about 300,000 cartons of molded plastic parts are hand stapled and hand palletized. Packaging engineers have written explicit packing and inspection instructions for packers as well as container and packaging material specifications. Suppliers are chosen by Purchasing on a cost basis though suggestions by the Shop and Engineering are usually seriously investigated. This department also checks incoming materials and containers for compliance with Engineering's specifications.

Packaging should protect and contain the product at a cost in line with product value so it can be transferred from the production line to the customer intact and on time.[9] It must be remembered, however, that packaging places requirements on other elements necessary to bring about this transfer,such as handling and shipping. It would be easy to consider reducing direct packaging costs as a major end in itself without consideration of its effect on related areas. A small increment in the

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[9]Nelson Jantzen, "Package Planning in the Physical Distribution Function," Handling and Shipping, 47, March, 1965.

cost of one facet can have a considerable effect on the others. Due to this inherent interaction, optimization of one element is not to be sought; rather, the goal should be optimization of the entire system.

Jantzen[10] considers the "system" to be optimized the physical distribution function and claims what is needed is an integrated relationship of packaging, handling, and transportation. He lists many elements that should be considered in establishing package design parameters. Those concerning sealing are:

1. Ease of packing and repacking at product line, warehouse, etc.
2. Ease of closing or reclosing at these locations or in storage areas.
3. Strength and surface properties to permit stacking in storage and transit.
4. Adaptability to unitization.
5. Protection adequate to withstand forces encountered in external movement.

The above and other considerations should be studied and weighed along with alternative packaging materials, labor, and equipment to discover profitable compromises.

August discusses this approach too,[11] but takes an even broader view. He emphasizes that you don't just design a package, but design the entire system to best utilize it. He includes forming, filling, sealing, etc. as well as distribution in his list of factors.

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[10] Ibid.

[11] August, Op. cit.

The author of this thesis has attempted to use the systems approach thoughout this work. Container prices can be deceptive. Though they are obviously important, more must be considered in the distribution of a product than the container alone. This is even more axiomatic when applied to a single factor of the container, in this case, sealing.

Importance of Case Sealing

But just how important a role does case sealing play in the distribution system? As long as you get the carton closed, what difference does it make how it's done? Unfortunately, the importance of proper sealing and closure is not always recognized. Like the weak link in any chain, it often takes its toll as a result. The best container in the world in engineering and materials can fail easily if not properly closed. This can take the form of spilling of contents, leakage or excessive distortion during shipment. In 1961 American railroads paid out almost 100 million dollars in loss and damage claims.[12] A survey carried out by the Fibre Box Association in conjunction with the railroads showed 4.5% of causes resulting in claims were due to closure failures.[13] Insurance rates also hold potential savings. These are initially estimated with a comfortable margin on the side of the

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[12] Export Packaging, Op. cit.

[13] Walter F. Friedman and Jerome J. Kipnees, Industrial Packaging, New York, John Wiley and Sons, 1960.

underwriter. If it can be later shown that few claims were placed, rate reductions may be requested. These are commonly granted and are often substantial.[14] Frequently, moreover, as at Western Electric, closure materials and operations are a major factor in packaging costs.

In line with the systems analysis it should be noted that apart from insurance and direct costs, sealing makes a big difference in operation on subsequent equipment in the line, in inspection procedures, and of course in general container servicability as a tool of distribution. For one thing, correct fastening of the flaps is necessary to insure rigidity of the container.[15] Stacking strength and compression strength in other major directions both suffer when inner and outer flaps are not positively joined.

Closure is defined as "a sealing or covering device affixed to or on a container for the purpose of retaining the contents and preventing contamination thereof, or the joint or seal formed in attaching the two parts..."[16]

Closure types utilized must comply with minimum appropriate carrier regulations. The Interstate Commerce Commission is the controlling body for truck, rail freight, and rail express.

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[14]W. P. Egan, "Road Transport and Packaging," Australian Packaging,31, January, 1965.

[15]E. C. Smith, "Packaging and its Relation to Modern Transport," Australian Packaging, January, 1965.

[16]Friedman and Kipnees, Op. cit.

Sections seven and eight of Rule 41 of the Uniform and Consolidated Freight Classifications cover sealing or closure regulations for rail shipment. Further sealing requirements are referenced in Rule 5 of the classification regulations.

Section 8 covers the sealing of other than slotted boxes. Section 7 covers the sealing of slotted and double wall boxes and is the one we will be concerned with in this study. (Section 7 is given in full in on page 71.) Assuming specified closure materials are used, these regulations may be capsulized as follows:[17]

Boxes must have both inner and outer flaps drawn together as closely as possible to insure a tight pack; lengthwise flaps must meet or overlap; no flap must project over edges; and boxes must be sealed by one of the following methods:

All flaps must be firmly glued over not less than 50% of the area of contact.

or Wide crown (1 1/4") staples may be used along the center seam only not more than 5" apart, but need only be used where the flaps overlap.

or 1" crown staples may be used along the center seams only not more than 2 1/2" apart, again only requiring use where the flaps overlap.

or All outer seams may be sealed with 2" wide sulphate non-reinforced tape.

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[17] A Packaging Handbook, Published by the Fibre Box Association, 224 S. Michigan Ave., Chicago 4, Illinois, pp. 65, 66, 1963.

or Center seams only may be sealed with 3" wide glass, sisal, or rayon fibre reinforced tape if it extends over the ends at least 2 1/2".

Regulations are given in detail in National Motor Freight Classification No. A6 and supplement for trucks and in Official Express Classification for rail express. These are essentially similar to the above.

CENTRAL PACKING STUDY

Total System

The central packing area was formed to insure that a group of people that were packing oriented and trained would do the majority of this work. The previous plan utilized a shutdown of lines and all production people packed. To really know when to centralize and when to decentralize requires a full knowledge of costs involved and equipment available.

Advantages claimed for decentralization are that handling is minimized, damage is reduced, errors are eliminated, floor space is saved, and manpower is better utilized.[18] Most of these are at least partially true and could have been applicable with Western Electric's products. On the other hand, the Indianapolis Works' central packing operation is a fairly efficient functional unit and most of the disadvantages decentralization was supposed to "cure" were only minimally in evidence under the system. Moreover, the advantage of familiarity and involvement with packaging principles did insure more efficient packaging labor and the large volume allowed the use of heavy, highly automated equipment.

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[18] "Decentralized Packaging: Another Key to Savings," Material Handling Engineering, 54, May, 1965.

The purpose of this paper is not to condemn or vindicate the central packing system, but to determine a closure system for it. To do this, however, the workings and interrelationships dictated by the system or heavily influenced by it must be understood.

For one thing, all packing is not centralized--theoretically only those facets where advantage is gained by so doing. The molding room, which handles most of the parts that might easily be marred by extra handling before closure, packs, seals and palletizes these units in the production area.

Furthermore, it is extremely doubtful that manpower would be more "efficiently utilized" under decentralization.

The stitcher in use at this time is run by one man. Two other men usually place containers on the feed conveyor from pallets though one could quite easily keep up with the operation in most cases.

A conveyor system takes the sealed cases back to merchandise where most of them are automatically palletized. A station previous to this point with a manual stop and sufficient accumulator conveyor backing it up is used to manually palletize certain cases that habitually do not palletize well on the automatic palletizer. Most of these are stitched cartons that are small and light.

Cases that are hand sealed in the central packing area (bulk packs that don't stitch well and coin collector packs that are full overlap containers) are sent to merchandise to be palletized on the same conveyor by merely raising the upper stitching head so it does not impede

progress of the larger packs. This obviously requires that stitching be discontinued. Since the same men do both jobs, however, and there are not enough stitchable containers to occupy all the conveyor time, little is lost. The stitcher is admittedly not being used to capacity, but this is better than using both the stitcher and the conveyors inefficiently.

Reference has been made several times to a conveyor system. This is quite intricate and was originally quite expensive, but without it neither the palletizer nor the glue sealer could be used at peak efficiency.

Needs

At the time of this study, the mean number of like containers in the central packing area was 31 and the median was 35. On three different occasions after there had been some accumulation due to down time of the stitcher or a rush for coin collectors, figures were collected for the number of final cartons of any one item. The mean was 67 and the median was 43. Approximately 75 lots a day would have run through a central packing sealer at that time and absorption of Washington Street would raise that to about 94.

Cases used in this area ranged in size from 6" x 6" x 3" to 24" x 18" x 18". Sixty-seven different sizes of final containers were used in this area. Ten or twelve different suppliers were represented in carton stocks at any given time. A wide variety of finishes were used including a couple of cases with bleached kraft liners and one with a heavy overlay of ink. Two color printing was used on several recently designed packs.

As explained, there is little marketing emphasis at this time. Trends seem to be, however, toward more inks, colored and bleached corrugated and institutional advertising in the near future. Another Mira Pak pouch making machine was being considered for the area; this would mean more light bulk packs with little support.

Certain plant-wide limitations were also in effect. The weight of cartons was limited formally to 65 pounds and informally to 45 pounds due to the requirements of Western Electric's union and others involved in handling, etc. Asphalt was not permitted in reinforced tape due to complaints of damaged finishes of parts after removal or storage in open cases. E flute corrugated may be used more in the future where primary considerations are strength and printability. At the present time this costs about 75¢ per MSF more than an equivalent grade of B flute.[19] Another innovation with relatively high probability is more color coding, particularly in respect to telephone sets and/or replacement parts for different styles.

Present Equipment

The Acme Stitcher (See Figure 1.) was procured in 1958 primarily because of its extreme flexibility and comparatively low materials cost (the only one near glue) plus the fact that it requires very little

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[19] Patrick A. Toensmeier, "E Flute Corrugated," Paperboard Packaging, 44+, November, 1963.

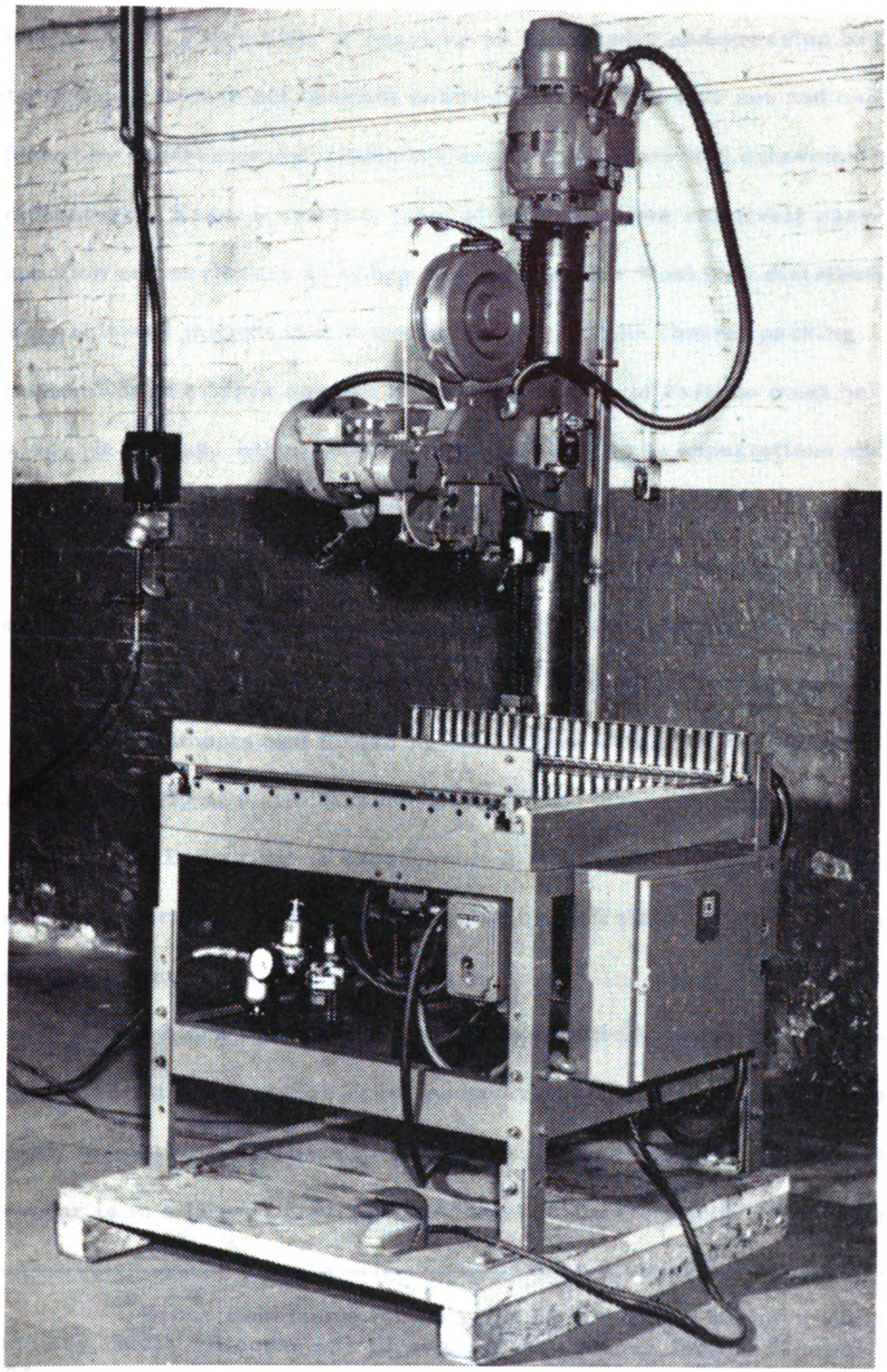

Figure 1.--Acme Silver Stitcher of the type used in the central packing area of Western Electric's Indianapolis Works.

floor space.[20] Moreover, it requires no subsequent compression or setting time, it does not obscure printed matter, and it is not radically affected by environmental conditions such as moisture and extremes in temperature. From a systems point of view it allows relatively easy inspection and reclosure at either the Indianapolis Works or distributing houses. It was thought that it would be ideal for the central packing situation where a large number of sizes and types of cartons must be sealed. It has not, however, turned out results up to expectations and is unsatisfactory for the following reasons:

(1) Maintenance costs have been high. The author found these to average $2,400/year since acquisition and they were projected to be $1,800 the year of the investigation. These costs were chiefly due to touchy adjustments and threading difficulties with both the original and a completely new stitching head.

(2) Down time is excessive. It is hard for the shop to schedule work and associated problems such as labor wait time are expensive in their own right.

(3) Much operator judgement is required. Good spacing can be obtained with care. It is easy, however, to do a bad job in relation to both spacing and tightness of stitching. This is especially true if the operator is in a hurry or rushed and the stitches are placed "on the fly."

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[20] Bruce Robertson, Packaging Engineer for Western Electric Company, Inc., Discussions throughout the period, June to October, 1963.

since packers are on wage incentive and bonuses are volume dependent, there is much temptation to take little care.

(4) Carrier regulations are almost never met due to faulty spacing and looseness. The author conducted several checks of goods waiting to be shipped out and found over 50% technically illegal. Of these, about half were insufficiently sealed from a practical standpoint.

(5) An otherwise good pack is no stronger than its seal. Loose stitching would stand few rough handling situations.

(6) There is a possibility of damage to preliminary containers and/or products due to malformed stitches. The author found no actual evidence of such damage in several merchandise checks and no complaints definitely due to such stitching in Quality Control's (Dept. 6315) complaint files. Several cases were found, however, where stitches were malformed and could have caused such damage had they been used on different products.

(7) There is danger to the Indianapolis Works' own personnel and those at distributing houses. Eight formal complaints had been received concerning injuries or near injuries. Most of these were dated shortly after the change to stitching, however, and the author suspects they were caused by not having the proper tools to remove the stitches. A small and inexpensive tool makes an otherwise difficult task quite easy. In any case, no complaints of this nature were received after June, 1960.

(8) Stitched cartons often do not palletize well on the automatic palletizer. Some cartons must be hand palletized that are of

sufficient size and weight to be machine palletized if sealed with tape or glue. It was further claimed that the stitches were hard on rubber rollers that were part of the palletizer.[21] No specific evidence of the latter was found.

(9) A generally sloppy job is done. A package should reflect the quality of the product contained and the company represented. Moreover, nobody likes to feel responsible for shoddy work and the author found the stitcher to be an almost universally disliked piece of equipment.

(10) The stitcher yields a small expected hourly output. Even considering its relatively quick adjustability, expected hourly output could be increased by about 30% using glue or tape sealers investigated.[22]

(11) Even if the operator is careful and other considerations are good, bulk packs from the Mira Pak and Sundstrand do not give enough support for a satisfactory stitching job.

(12) Stitching often does not penetrate both flaps. When inner and outer flaps are not positively joined, there is a loss in stacking strength and more loss in compression strength in the other major dimensions. Under compression, the inner flaps have a tendency to depress inward, yielding to rather than resisting the energy applied.

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[21] Richard Asbury, Merchandise Manager for Western Electric, Inc., Discussions throughout the period, June to October, 1963.

[22] Paul Fromm, Wage Incentive Department, Western Electric Company, Inc., Discussions throughout the period, June to October, 1963.

(13) Stitching provides no barrier against the entry of moisture or foreign matter.

(14) This method makes the detection of pilferage very difficult since no damage need be done to the case to open it.

Analysis of Alternatives, Qualitative

Many methods were discounted for a glaring qualitative reason or a combination of several that made the approach unreasonable or unreliable. Those thought at least possible were considered at a finer quantitative level as well as the former. Finally, choices of materials, accessories, and equipment of the proposed change were investigated to find an optimum working unit to fit into the existing or modified central packing subsystem and broader Western Electric systems.

Hand operations will be covered first:

Three Strip Non-reinforced Taping

Standard gummed tapes are sulphate paper (kraft) with water activated animal or vegetable glue or dextrin adhesive.[23] Usually animal glue is the principle ingredient.[24] These may be used to close cases for shipping only by sealing all seams. Since automatic taping

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[23] "Guide to Packaging Tapes," Modern Packaging Encyclopedia for 1963, 235, Modern Packaging, New York.

[24] A Packaging Handbook, Op. cit.

equipment now available can only apply tape in one direction[25] this tape can only be used in a hand operation.

Advantages of gummed tapes according to Friedman and Kipnees[26] are that:

(1) When properly moistened and applied, they provide excellent protection against handling and shipping hazards.

(2) If all open seams are covered with tape, protection against contamination by foreign matter is provided.

(3) Imprinting of tapes enables the carrying of inexpensive messages for advertising, product identification, instructions, etc.

(4) Small compact dispensing equipment is available which permits flexibility of the taping operation in small packaging areas.

(5) Reuseability of container due to ease of opening is facilitated.

It may be quickly noted that four of the claimed advantages apply little or not at all to the central packing area. Add to this the facts that the materials cost is higher than for most other methods, labor costs are very high for manual application of tape, and water activation and frequent lack of control of the adhesive bond often give poor seals, and a substantial case has been built against this method. Stacking strength and compression strength would be adversely affected since taping does not effectively join inner and other flaps as all other considered methods do.

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[25] Friedman, and Kipnees, Op. cit., p. 374.

[26] Ibid., p. 369.

Single Strip Reinforced Taping

Reinforced tapes house glass, nylon, rayon, or sisal fibres in an asphalt or rubber based layer between two layers of kraft.[27] Both asphaltic and non-asphaltic tapes are now available with a diamond (three-way) pattern.[28] This supposedly gives better tear strength at corners, but still does not counteract the loss of stacking and compression strength by taping. The Indianapolis Works, as has been stated, is already using this method for some bulk packs. A problem has frequently come up when tape has not been suitably moistened or applied, in that the tape has not been even adhered to both outer flaps. Moreover, some cases could not be turned over and the volume is simply too large to ignore the advantages of an automatic unit. Materials costs will be seen to be out of line in comparison to other methods. (These would be the same as those shown for automatic taping in Table 1.)

Pressure Sensitive Taping

Pressure sensitive tapes consist of a soft backing material with a pressure sensitive adhesive mass on one side. These have the advantages of simplicity of application, adherance to all surfaces, the possibility of using the backing material for identification, merchandising appeal, strength and water and/or vapor resistance, and easy adhesive formulation modification to fit various requirements. Further

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[27] "Guide to Packaging Tapes," Op. cit.

[28] "Reinforced Tapes," Package Engineering, 144, November, 1964.

advantages over water activated tapes, are instantaneous adhesions and no setting delays, less complicated dispensers, no moistening is required, and cases are easier to open.

Average adhesions are available up to 70 ounces per inch of width and average tensile strengths are available even in non-reinforced tape to 60 pounds per inch of width. The big disadvantages are again volume allowing automation, turning already filled containers upside down, loss in stacking and compression strength, and a very high materials expense.

Self Sealing Boxes

Self sealing boxes were also discounted. Yearly cost would be approximately $10,000 more than a glue sealer. Also, there is only one supplier in the area (St. Regis). This would put Western Electric not only at a pricing disadvantage, but could lead to problems during sudden fluctuations of need and indirectly to inventory and storage problems.

This form of sealing could be more economical for companies using a variety of case sizes in small quantities. One company that used thirteen different case sizes fully randomly rather than by lots replaced two men and a stitcher with one man by using these.[29]

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[29] "Pre-Applied Adhesive Speeds Box Closing, Ends Stacking Failure," Package Engineering, 87-89, April, 1964.

Their major advantage would be realized in packing at manufacturing stations to save handling and eliminate pans altogether. This by definition, would not be feasible and would negate many of the advantages of central packing. These might be used to advantage, however, at molding and on the bulk packs of the Sundstrand and Mira Pak. The latter use is also doubtful since self seals depend on stacking pressure to contribute to a positive seal and these are rather light packs.

Hand, Air and Electric Portable Staplers

Stapling differs from stitching in that it uses a preformed metal fastener which is dispensed, usually from a magazine fed machine. Stitching, on the other hand, forms its own fasteners as it clinches from a continuous roll of wire.

Air driven machines are purported to eliminate operator fatigue though the guns are somewhat heavy and cumbersome. It is claimed that hand operations have fastened 144 cartons in 22 minutes with 20 staples per carton.[30] Figures the author obtained by observation and checked with Paul Fromm[31] of Western Electric's Wage Incentive Department were much less impressive, however.

Mechanical hand staplers are used presently in molding and for special operations and coin collectors in central packing. Many of

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[30]Sherman L. Smith, "Stapling Equipment," Modern Packaging Encyclopedia for 1963, 600-601, Modern Packaging, New York.

[31]Fromm, Op. cit.

the disadvantages--and advantages--enumerated for the existing stitching operation would apply. Furthermore, labor would be considerably higher in comparison with all alternatives seriously considered and materials costs would surpass all but reinforced tape. Judging from maintenance records, they would gain back a bit of the advantage there. (See Table 1.) The hand operation does not lend itself well to the handling necessary or quantity in the central packing area and would cost $20,000 more per year than a glue sealer.

Automatic Taper

The safety of a seal utilizing gummed tape depends primarily on the bond or grip between the sealing tape and the container surface. This in turn assumes the glue to be of a sufficiently good quality and suitable for the purpose and that the glue will be conditioned by moisture to the proper consistency for quick, deep penetration into the carton's outer liner.[32] Failure such as Western Electric experienced with hand applied tape is almost always caused by faulty application rather than defects inherent in the tape. Therein lies the advantage of automatic taping equipment--almost all elements of chance are eliminated. Moreover, automatic taping equipment is generally more economical for high volume operations.

A taper would be good from the point of view that the product could in no way be damaged by the sealing operation, and housekeeping

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[32]"Equipment for Applying Tape," Modern Packaging Encyclopedia for 1963, 602, Modern Packaging, New York.

would be easier than with a glue sealer. Present automatic tapers can only apply tape in one direction limiting use to reinforced tape (See Appendix). A 2 1/2 inch extension is required by carrier regulations, however, over the ends on both the top and bottom. This would cover advertising on some shipping containers (probably more in the future) and code markings. If code making was postponed until after sealing, extra handling would result and identification errors would be likely. This would also be more expensive than a glue sealing operation by about $11,000 per year, mostly due to the high cost of reinforced tape. Stacking strength and compression strength, for reasons mentioned previously, would again be lowered.

Automatic Stapler

"Automatic" stapling of sorts is available although the adjective is used a little more loosely than in reference to gluing and taping equipment. An operator is normally required at the machine which is commonly foot pedal operated. By using two heads, most can be arranged to seal tops and bottoms of loaded cases simultaneously, as would be advisable in central packing.

Bostitch has a new sealer which utilizes coil staples and feeds 4,000 per head without reloading. It operates on 70-90 p.s.i.[33] which is already available in the area. Speed attainable is about 400/hour

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[33] "Bostitch Develops Coil-Feed Head," Packaging Digest, 13, January, 1965.

(about 6 2/3 per minute).[34] This is comparable to present equipment. It's major advantage is flexibility as it can be used with cartons varying as much as 8" in height without adjustment.[35] Central packing cartons vary much more than this, but a little thought in scheduling production sequences could minimize adjustments.

Annual costs would be about $10,000 more than a glue sealer. Almost all of the advantages and disadvantages stated for an automatic stitcher would also apply for an automatic stapler and it was felt that little would be gained by such a change.

Glue Sealer-Proposed Change

As will be seen, a glue sealer is by far the most economical alternative if its use is feasable in the central packing area. Furthermore,it will give less tangible benefits in the forms of a surer seal and pack, a neater job reflecting Western Electric's level of product quality, consistently met carrier regulations and a fuller range of palletizable cartons with less strain on automatic equipment. Increases in good will would be achieved both in their distributing houses and the shop due to the elimination of danger from malformed stitches and pride of workmanship.

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[34] "Versatile Bostitch Machine," Packaging Digest, 8, April, 1965.

[35] "Economical Top and Bottom Stapling Unit," Paperboard Packaging, 98, January, 1963.

Potential disadvantages of the proposed change are wait time until the last container clears the compression unit, more floor space, the possibility of difficult sealing surfaces, especially inked containers such as the Call Director, frequent cleaning and maintenance problems due to manual adjustment. Bottom pads may also have to be added or a change made to center special slotted containers on some bulk packs. There is a possibility of a difficulty similar to that observed with the stitcher sealing bulk packs or others with little inner support and a possibility of getting glue on expensive equipment such as the Call Director. As will be explained later in this work, many of these disadvantages will be eliminated or made negligable if a resin rather than a dextrin adhesive is used.

Economic Overview

Kaye Holstebro[36] states that gluing is most economical, then stapling, and then taping, considering any volume. Friedman and Kipnees[37] concur, "if operating conditions permit the use of semi-or fully-automatic equipment as well as adequate automatic means for compressing the sealed package after application of the adhesive."

These predictions were borne out in the author's findings concerning Western Electric's central packing area. A glue sealer

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[36]Kaye Holstebro , "Caseloaders, Gluers, Sealers," Modern Packaging Encyclopedia for 1963, Modern Packaging, New York.

[37]Friedman and Kipnees, Op. cit., p. 356.

was estimated to save roughly $8,000 a year over existing equipment and up to $20,000 a year over other alternatives even using a surer, more expensive adhesive than was being used by them in their merchandise area. See Table 1.

TABLE 1.--Annual costs of sealing alternatives.

	Materials	Labor	Maintenance	Total
Acme Stitcher	$ 4,322	$13,837	$2,400	$20,859
Glue Sealer (Dextrin)	1,021	8,675	1,500	11,196
Glue Sealer (Resin)	2,500	8,675	1,700	12,875
Tape Sealer	14,404	8,850	1,200	24,184
Automatic Stapling	8,466	13,837	1,200	23,503
Hand Stapling	8,466	23,500	500	32,506

Materials and labor costs for the above were computed considering all containers in regard to their respective volume used in central packing the year previously and those that would go through when the Washington Street production was absorbed (1,144,000 per year). Formulas for materials costs are shown in Table 2.

TABLE 2.--Formulas used to determine materials costs.

Glue*

$$\text{Central Packing Cost/Year} = \left(\text{No. cases/year in central packing}\right) \left(\frac{\text{No. barrels/year used in merchandise}}{\text{No. cases/year in merchandise}}\right) \text{(Price/barrel)}$$

Stapling

$$\text{Central Packing Cost/Year} = \left[\sum_{\text{All carton types in central packing}} \left(\frac{\text{width}}{2.5}\right) \left(\text{No./year of this type of carton}\right)\right] \left[\text{Cost/staple}\right]$$

Stitching

$$\text{Central Packing Cost/Year} = \left[\sum_{\text{All carton types in central packing}} \left(\frac{\text{width}}{1.25}\right) \left(\text{No./year of this type of carton}\right)\right] \left[\frac{\text{Cost/roll}}{\text{Avg. no. stitches per roll}}\right]$$

Non-Reinforced Tape

$$\text{Central Packing Cost/Year} = \left[\sum_{\text{All carton types in central packing}} (2 \times \text{length} + 4 \times \text{width} + 12) \left(\text{No./year of this type carton}\right)\right] \left[\frac{\text{Cost/roll}}{\text{No. inches/roll}}\right]$$

Reinforced Tape

$$\text{Central Packing Cost/Year} = \left[\sum_{\text{All carton types in central packing}} (2 \times \text{length} + 10) \left(\text{No./year of this type of carton}\right)\right] \left[\frac{\text{Cost/roll}}{\text{No. inches/roll}}\right]$$

*The formula given for glue is not the one that would be used if Western Electric were to strive to apply only in minimum carrier requirements. Though patterns can be varied easily using some pressurized application systems these figures were calculated assuming a constant pattern. This--considering the large number of small cartons in central packing and the consistently large cases in merchandise--was in line with other efforts to be conservative in promised differentials.

A formula that could have been used to find materials costs using only minimum carrier requirements in both areas would be:

$$\text{Central Packing Cost/Year} = \left[\frac{\text{No. barrels/year used in merchandise}}{\sum_{\text{All carton types used in merchandise}} (\text{Width}^2) \quad (\text{No. of cases of this type/year})} \right] \times \left[\sum_{\text{All carton types used in central packing}} (\text{Width}^2) \quad \left(\text{No. cases of this type/year}\right) \right] \left[\frac{\text{Cost}}{\text{Barrel}} \right]$$

These are, except for glue, minimal to meet carrier regulations, sufficient for prevailing conditions and generally in accord with Indianapolis Works' practices where these sealing methods were already in use.

The upper materials cost and total cost for the glue sealer in Table 1 assume use of the dextrin glue used in merchandise. The lower figures illustrate costs using a "resin" adhesive (a polyvinyl acetate emulsion). Volume used was assumed the same to be conservative in savings estimates. Trends the author noted in his merchandise study (p. 59), however, suggest that a 25% reduction in glue volume used would not be out of line, reducing the resin total to about $12,000.

Labor rates were calculated using base hours for appropriate methods at a rate of $2.67 per hour. A conveyor speed of 60 feet per minute was assumed which is in line with the present conveyor system. Speeds actually range from 30 to 85 feet per minute and adjustment in some cases would have to be made to fully utilize new equipment.

Maintenance costs of the stitcher are an average of those incurred since its acquisition. Those of the glue sealer are estimated assuming more trouble will be encountered than the $860 yearly average since its automation and placement in merchandise and less than the $2,530 average before this change. This drop partially resulted from a 40 per cent decrease in volume of containers sealed, partially because of the minimizing of manual adjustment, range and variety of

carton sizes sealed to three similar sizes, and partially through changes in application and overload assemblies. Changes made are now stock or generally offered options on sealers under consideration and the volume including Washington Street's contribution will be slightly more than the present merchandise volume. Numerical presetting equipment is available to minimize operator judgement necessary, but there will be more maintenance due to frequent settings than on the merchandise unit.

Acquisition cost estimates were in most cases not directly sought as the author was advised to avoid overencouraging any suppliers. It was realized that many alternatives would be rejected for other reasons and it was considered discourteous to put these companies to the extensive calculations needed to offer firm quotes. Moreover, Western Electric's purchasing department determines the price with manufacturers involved after considering features and preferences requested by engineering and shop personnel. Estimated acquisition prices are shown in Table 3.

TABLE 3.--Acquisition costs of alternatives, estimated.

Glue Sealer, presettable for next lot, installed	$15,000
Glue Sealer, random, installed	25,000
Tape Sealer, adjustable	10,000
Tape Sealer, random	25,000
Stapler, adjusted by lots	10,000

Economic characteristics are of course not the only factor to be considered in closure selection. Their interaction must be contemplated along with protection requirements, carrier regulation, and the entire distribution system.

Depth Analysis of Glue Sealer Characteristics

The installed cost of a Fergusen glue sealer investigated by Bruce Robertson,[38] Department 845, in 1960 was $14,000. This included JIC (special wiring) and pre-settability for the next carton size to be run. A completely random unit made by Union Bag and Camp could be installed for $25,000. This has the advantage of requiring no compression section (complete unit only 10 feet by 4 feet) and will run at a maximum rate of 12 containers per minute.[39] This would not seal some of our large volume, small width containers or a few of our largest, however. It utilizes a very expensive, but very effective, hot melt adhesive. Only one is in service despite several years of advertising which would probably mean extensive developmental costs on the part of Western Electric. General Corrugated has a similar machine available.[40]

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[38]Robertson, Op. cit.

[39]"Automatic Random-Size Case Sealer," Paperboard Packaging, 78, April, 1964.

[40]"Case Sealer," Package Engineering, 123, August, 1964.

A completely random adaptation of the Fergusen was investigated by Russ Dazey,[41] Department 841, and a $12,000 figure was arrived at for the conversion. This would give an approximately equal total ($26,000) and a surer share of developmental costs. Union Bag's advantage of no compression unit would not be gained nor would the rate be equalled, without changing to a hot melt. It is possible, however, that the range of carton sizes could be widened.

In any case, the random unit is not necessary or particularly advisable in the central packing situation. Palletizing and merchandising functions as well as wage incentive crediting of makers, packers, and inspectors, dictate that cartons be run in lots rather than at random. As stated previously, the mean number of like containers in the central packing area was 31 and the median was 35. Accumulation regularly takes this significantly higher, but even without it and considering pallet loads rather than total numbers, it is practical to change between lots if changeover time is short. (Merchandise pallet loads only number 16 and 24 though up to 96 can sometimes be run between size changes.)

Presettability for the next lot is desirable since it would minimize slack time under normal conditions, using two men to feed cartons and over-see the line. Three men are typically used with the stitcher and only about half the output rate of a glue sealer is realized.

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[41] Russel Dazey, Mechanical Engineer for Western Electric Company, Inc., Two discussions during July and August, 1963.

This system is such that one man could handle the line when other packing chores needed extra labor. Output rate would be of course lower in such cases, but resulting scheduling flexibility might make this temporarily profitable.

The application method utilized should be a totally enclosed, pressurized glue system. This is considered by Kaye Holstebro[42] to be the key recent development in case sealing. Though the author would not go to such lengths, it does offer several desirable features. Glue will flow only when the sealer is running and nozzles are in contact with carton flaps.[43] This allows flexibility in feeding when necessary. Engineering had modified the merchandise gluer with such a system a year previous to this study. Glue heads were lifted by running over the flaps themselves and some trouble was encountered when heads partially clogged with kraft. This was never serious enough to affect sealing, however, and systems are now available with cam-activated nozzles to prevent this.[44]

Since the system is totally enclosed, glue is not exposed to air and it can't set up. This would be especially important if a resin were used due to the increased clean up difficulty once hardened. Some

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[42] Holstebro, Op. cit.

[43] "Adhesive Application Systems," Paperboard Packaging, 78, April, 1964.

[44] "Pressurized Cold Glue System for Corrugated Containers," Paperboard Packaging, 199+, December, 1964.

trouble was encountered by the author in leakage at the nozzles of the existing pressure system. This was minimized with adjustment, but not completely eliminated.

Problems faced previous to the pressure adaption of the merchandise sealer were discussed by the author with Russ Dazey and Dick Asbury. These had been predominantly based on lack of control, causing glue damage to contents and the glueing of intermediate packs to finals. This would be expensive to correct by switching to center special slotted containers or top and bottom pads for all carton sizes in central packing. (This will be necessary in the case of a few bulk packs in any case.) Added carton or materials expense and, in the latter case, added inventory, would be unnecessarily incurred.

ADHESIVE ANALYSIS

General Principles

As Jastrzebski[45] defines it, "An adhesive is any substance capable of holding materials together by surface attachment." In most applications the adhesive bond should have a tensile strength equal or greater than the surfaces to be bonded.[46] (Easy open applications are an exception.) In any case, a satisfactory adhesive must adhere well to the surfaces it is bonding and have good cohesive strength. If the liners bonded are relatively clean and rough, adhesion at the interfaces is usually even greater than the strength of the adhesive. A roughened surface allows mechanical bonding caused by interlocking and wedging of the adhesive in surface crevices to supplement chemical adhesion.

Most adhesives are organic materials and their strength decreases rapidly at higher temperatures.[47] Despite this claim by Jastrzebski , many new resin emulsions have been developed with

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[45] Zbigniew D. Jastrzebski, Nature and Properties of Engineering Materials, New York, John Wiley and Sons, 1959.

[46] Friedman and Kipnees, Op. cit.

[47] Jastrzebski, Op. cit.

good resistance to high as well as low temperatures.[48] Water glass (sodium silicate) is the only prominant inorganic case sealing adhesive.

Variables

Just what are the variables involved in choosing an adhesive? These are many and include variables in the adhesive itself, variables and limits imposed by sealing equipment, those inherent in the carton type or types to be sealed, those concerning handling and distribution, and those having to do with the physical environments encountered in packing and distribution.

Different specific variables may be overbearing depending on needs. Friedman and Kipnees[49] view some of the generally most important selection criteria as:

1. Jute, cylinder, or Fourdrinier kraft (dry finish, or water and steam finish).
2. Rate of setting, which is a function of the speed of application as well as the time under compression and tension factors (flaps, etc.) of the container.
3. Specific end use requirements for water resistance, easy openings, etc.

Dr. W. Vollmer[50] emphasizes that the absolute value of bond strength depends greatly on sealing conditions. He considers major

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[48] "Adhesives: The Key to Better Packages," Modern Packaging Encyclopedia for 1963, 224-236, Modern Packaging, New York.

[49] Friedman and Kipnees, Op. cit.

[50] Dr. W. Vollmer, "Influence of Climate and Humidity on Corrugated Board," Paperboard Packaging, 128, December, 1964.

variables to be the moisture content of board, adhesive consistency, thickness of application, temperature, and speed. George Rice[51] believes that substrates are the most important factor in adhesive choice today. This is quite true in the case in question. Though the range does not involve materials as impervious or difficult to bond as those to which he refers, a great variety of boards is used in their central packing. This also turned out to be one of the Indianapolis Works' major problems in its merchandise sealing area, with a much smaller selection of boards and finishes.

Perhaps a better way to look at the problem of sealing variables is to consider those pertinent that affect the overall effectiveness of the container in performing its functions of protecting and containing the product through storage and distribution channels and representing the manufacturer and product. This encompasses a surprising number of items, but fortunately the effects of many may be made negligible by proper choice of sealer and adhesive. The author will now examine a few considerations and show how they affected or could affect operations at Western Electric:

Carton Variables

Much of adhesive selection depends on just what is to be sealed. The pure physical size or variation in sizes of containers or

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[51] George D. Rice, "Learn Your Adhesive Needs Before Jumping to Hot Melts," Package Engineering, 65-69, February, 1964.

production sequence may dictate the amount of automation or randomness of sealer desirable, necessary, or possible and thereby indirectly, the types of adhesives useable. The tightness of fill may necessitate adhesives with relatively fast tack as in the case of bulk packs from the Sundstrand and Mira Pak machines. The weight of the filled pack may help determine the tension or length of compression units. The length to width ratio dictates the ratio of sealed area to unsealed and also torsion stresses that may be brought to bear. Moisture content of the board has an effect on bond strength.[52]

Two of the most important variables in Western Electric's merchandise area were found to be liner type and surface treatments. These can vary quite markedly from manufacturer to manufacturer in theoretically "comparable" grades and of course are consciously varied for different uses and effects by any given manufacturer.

A heavy starch sizing will make bonding more difficult, but is sometimes the only way the required mullen test for shipping requirements can be obtained by the manufacturer.[53] It may be necessary if using a starch adhesive, to apply excess adhesive or increase the percentage of solids. Wet strength liners may be handled similarly. Polyvinyl acetate emulsions have been developed that give great stability and non-separation on the toughest clay coated and wet strength

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[52]Vollmer, Op. cit.

[53]C.R. Vander Meulen, "Waterproof-Starch Corrugating Adhesives," Paperboard Packaging, 68+, June, 1963.

boards.[54] Some resin emulsions in fact will perform well on almost all surfaces, including glass.[55]

The felt side may be considerably harder to bond than the wire side. Printing or other considerations may make it advisable to have cartons with felt sides out at least in the outer liner. Here again, trials by the author with a resin adhesive showed no difficulty in obtaining satisfactory bonds.

Sealer Variables

Certain items are variable on a given sealing system or from one system to another. The speed of line and open time affect penetration and may make it advisable to use more or less viscous adhesives. Hot melts can minimize open time since they bond through disippation of heat rather than of water or solvents. Type of application may be pot and roller, pressure or spraying. The pot and roller method uses more adhesive, but the thickness can be somewhat controlled by a blade next to the roller. Pressure may be varied in other systems affecting both amount and penetration of the adhesive. These will be discussed in the adhesives portion of this section. The agitation and shearing action of pumps in recirculation may cause a breakdown of viscosity in conventional starch adhesives. The tension and

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[54] "Coatings, Adhesives, and Inks," Paperboard Packaging, 195, July, 1964.

[55] "PVAc Emulsion for Adhesives," Paperboard Packaging, 149, October, 1964.

length of compression unit used or allowable will determine along with speed, the basic type of adhesive desirable. It will also influence viscosity and additives necessary to achieve desired penetration and bonding characteristics. Angles in piping should not be sharp or the danger of adhesive stagnation exists.

Distribution and Storage System

The form of distribution and handling system in which the package must function is important. The distance and number of handlings have their effect, as does whether handling is primarily by man or machine. When and if inspection or quality control checks are made play a part. The type of carriers involved should be considered as should the variety and locations of destinations. The length of time in storage and of course environmental conditions which will be covered separately next must be considered.

Environmental Conditions

Environmental conditions are treated separately due to their importance in both the sealing area and subsequent distribution and storage. Effects are somewhat different, but temperature and humidity are the two most important factors in both cases.

The bond strength depends greatly not only on the sealing temperature but on the moisture content of the board, and therefore, humidity of sealing and container storage. Both embrittlement and

excessively high humidity have been found to reduce adhesive strength.[56] Too much heat, especially at low speeds, is one of the major causes of brittle bonds. Ways to counteract this effect include increasing solids content of a starch adhesive or reducing its caustic or borax content--or simply applying an excess of the adhesive.[57] Cartons with heavy outer liners that have just been brought in from the outside in winter or are, for other reasons, cold, should be allowed to warm up before running.

Storage and shipping conditions are also demanding as bond characteristics may change markedly on aging. New adhesives are being constantly developed to meet such challenges squarely. Polybond, for instance, claims it has a resin emulsion that bonds well to all board stocks, and whose cured bond resists temperatures between 450°F and -20°F with good aging characteristics.[58]

Adhesive Variables

Considering the matter from the standpoint of the adhesive itself, many aspects can be varied. Some have been mentioned briefly in connection with their determinants and/or effects.

Failure within the adhesive itself usually is caused by the propogation of cracks which are accelerated by the presence of

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[56] Vollmer, Op. cit.

[57] Vander Meulen, Op. cit.

[58] "Resin Emulsion Adhesive," Package Engineering, 176, September, 1963.

discontinuities and flaws.[59] For this reason it is better to use thin layers of adhesive as long as they sufficiently cover the interface. Less plastic deformation occurs and fewer flaws are likely.

The basic type of adhesive of course must be chosen. These will be thoroughly covered later in this chapter, however, and so will not be discussed at this point.

Viscosity is one of the most important variables as it governs wetting power and penetration (Wetting power can also be adjusted by varying solution temperature and water content.) Higher viscosity decreases wetting and penetration and this can be raised by lowering the temperature and/or using less water. A lower viscosity is usually more advantageous on heavily calendered or sized liners. Optimum viscosity allows better penetration, but is more difficult to apply and may make housekeeping more of a problem. The cause and effect may be reversed in the case of starch adhesives. Poor housekeeping may allow contamination by certain types of bacteria which thrive on starch and can make viscosity control impossible.[60] Formaldehyde or other preservatives may be added to guard against such contamination. While in solid adhesion, tensile strength, shear strength,

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[59] Jastrzebski, Op. cit.

[60] Foster G. Ewing, "Critical Factors in Preparation and Use of Corrugating Adhesives, Paperboard Packaging, 77, May, 1963.

and impact strength are important, in the liquid (primary) adhesion, viscosity is the major source of bond strength.[61]

Closely related to viscosity is per cent solids. The per cent desirable may vary with the basic type of adhesive and with its use. Polyvinyl acetate emulsions are normally purchased at about 55% solids,[62] while 20 to 30% is high for polyvinyl alcohol.[63] Only about 19-21% is common in starch adhesives used for corrugating (somewhat higher for case sealing). An even smaller percentage is used at times, but normal quality variations in liners may result in poor sealing if this is done. A higher solids adhesive is recommended by Vander Meulen[64] when cartons are especially cold.

Another obviously related property is penetration. This can be influenced by several factors already mentioned such as viscosity. Moreover, it may be minimized by adding clays or gum additives to starch adhesives, the latter allowing maintenance of a stable viscosity level. Penetration can be increased by adding wetting agents.[65] The addition of urea will not only increase penetration, but will minimize

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[61] Jastrzebski, Op. cit.

[62] Ewing, Op. cit.

[63] John Dovris, Technical Representative for National Starch and Chemical Co., Telephone conversation on July 9, 1965.

[64] Vander Meulen, Op. cit.

[65] Ewing, Op. cit.

thixiotropic properties[66] (the tendency to become "livery" in shallow pools such as glue pans). Cold water starches are pregelled, dried and ground to the desired mesh size, thereby affecting penetration.[67] Hot melts are essentially instantaneous with little penetration in even the most porous surfaces.

Starch adhesives may contain caustic alkali solution and/or borax in variable amounts. A higher alkalinity at a given viscosity increases wetting and penetration and reduces gel temperature where uncooked starches are used.[68] Adding borax improves both viscosity control and runability. It generally produces a heavier and more viscous carrier.

Tackiness, as Jastrzebski[69] puts it, "represents the combined effects of many phenomena such as adhesion, cohesion, surface tension, viscosity, and yield value." An adhesive must be applied in a liquid form to make a bond. Fast tack, such as many resin emulsions have, allows bonds to be made almost instantaneously. The full need for this is not realized on case sealers but on such equipment as carton making machinery where National Starch claims to be able to run at

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[66] Vander Meulen, Op. cit.

[67] P. A. Spenadel, "How Cold Water Starches Help Corrugating," Paperboard Packaging, 66+, June, 1963.

[68] Ewing, Op. cit.

[69] Jastrzebski, Op. cit.

rates of 16,000 boxes/hour.[70] Hot melts may be even quicker since they bond through dissipation of heat rather than water or solvents and essentially require no open time.

Case Sealing Adhesives

The author would like to limit this discussion to adhesives commonly used for relatively large volume case sealing operations. The 1963 Modern Packaging Encyclopedia's, "Adhesive Selector Chart"[71] considers only borated dextrins, vinyl acetate resin emulsions and hot melts (solid resins). Only the resin emulsion and hot melt were considered when the use dictated water resistance and if this was because of export, hot melt too was eliminated. Only the resin emulsion and borated dextrin were recommended for uncoated paperboard and the borated dextrin was eliminated when compression time was less than 20 seconds.

Though the chart seems to point definitely and unvaryingly toward a resin emulsion, the author would like to look a bit deeper into the adhesives considered and a couple that were slighted. Friedman and Kipnees,[72] for instance, in an earlier publication (1960) still considered silicate of soda (water glass) important and it was given

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[70] "Films, Coatings, and Adhesives," Paperboard Packaging, 152, October, 1964.

[71] "Adhesive Selector Chart," Modern Packaging Encyclopedia for 1963, 225, Modern Packaging, New York.

[72] Friedman and Kipnees, Op. cit.

along with resin emulsions and dextrins as one of the most widely used for case sealing. Hot melt, though discussed, received less emphasis than in some subsequent works.

Silicate of Soda (Water Glass)

This is one of the few inorganic adhesives. It has good water resistance, and is very inexpensive. It is, however, hard on automatic equipment and is extremely hard to clean up. Special materials are available to keep glue from sticking to machinery. An oil mist spray helps, too. This is probably the reason for its exclusion from selection charts; it is still used for case sealing, however, and should be considered.

Borated Dextrins

Starches and dextrins are the base of the largest single class of packaging adhesives.[73] Processing improvements and better quality control have resulted in more uniform products and reduced waste over former vegetable adhesives. Converting starches to dextrins gives quicker tack and high solids in a machinable adhesive. Borax is usually added to improve setting speed, adhesion and economy. Borated dextrins usually have fairly good high humidity resistance and final adhesion--especially the less converted types.[74]

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[73] "Adhesives: The Key to Better Packages," Op. cit.

[74] William W. Sederland, "Summary of Packaging Adhesives: Types, Properties, Uses," Modern Packaging Encyclopedia for 1963, 228-229, Modern Packaging, New York.

Vegetable adhesives have excellent storage characteristics, are orderless, non-toxic, and clean machining (superior to all other adhesives). They are somewhat susceptable to changes in temperature and humidity and Western Electric had some trouble due to container variations and insufficiently fast set.

Hot Melts

Hot melts are composed of resin and/or waxes. They are available in solid and semi-solid forms and must be liquified by heat to produce adhesion. They contain no water or organic solvents and therefore have quick setting times and are successful in bonding difficult surfaces. If they are wax or crystaline resin based they commonly lack toughness and adhesion at temperature extremes (some thermoplastics cold flow at 140° to 160°F)[75] but liquify over a narrow but defined temperature.[76] Higher molecular weight resin based adhesives give better toughness, adhesion and flexibility at temperature extremes. One such hot melt requiring 2 or 3 seconds bonding time maintains its bond to -50°F after sealing.[77] These higher molecular weight resin adhesives tend to be more difficult to use since their melting point is poorly defined and higher reactivation temperatures are required.

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[75] Rice, Op. cit.

[76] Sederland, Op. cit.

[77] "Hot Melt Adhesive," Package Engineering, 174, April, 1964.

These are very expensive and use different methods of application since heating is required (usually 250 to 400°F).[78] Their fast set allows small compression units while still giving good strength. Little clean up is required since they are thermoplastic and melt again on reheating.

Latex Adhesives

Latex adhesives are really a form of resin emulsion. They are treated separately because of a couple of significant properties that make them unique from the standpoint of case sealing.

They may be based on either natural or synthetic rubber latex. Natural rubber latex adhesives have one common property--when dry,these adhesives stick only to themselves.[79] The adhesives are not of course seriously being considered for use in a sealing machine in the central packing area. They are, however, the basis for St. Regis's self sealing cartons considered earlier and for this reason have been included. Instantaneous,tamper-free bonds are claimed with no risk of stack adhesion.[80]

Permanent strength and adhesion of those based on synthetic resins are claimed even better than their natural-based counterparts.

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[78] "Adhesives: The Key to Better Packages," Op. cit.

[79] Ibid.

[80] "Self-Sealing Adhesives," Paperboard Packaging, 100, November, 1963.

Even most difficult surfaces may be sealed and dried films are very water resistant. Naptha may be required for cleanup.

Resin Emulsions

Emulsions are small spheres of resin or water insoluble substances suspended in water.

Both natural and synthetic resins can be made into emulsions which may serve as adhesive bases. Advancement in polymerization techniques has introduced new copolymers with practically any desired set of physical and chemical properties. Plasticizers, tackifiers, fillers, etc. can be used to further modify the adhesive properties.

Polyvinyl acetate is the most widely used resin for this purpose, but in addition to it and its copolymers, acrylics, phenolics, rosin and its derivatives, butadiene-styrene, neoprene and other rubberlike polymers are used.[81] Polyvinyl alcohol is a relatively inexpensive resin adhesive, in some cases being sold below prices of even starches and dextrins. According to R. L. Hawkins,[82] moreover, it, " ...is the best adhesive known for cellulosic materials." It has many of the advantages of polyvinyl acetate,including excellent bonding, increased permissable speed, and stability.

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[81] "Adhesives: The Key to Better Packages," Op. cit.

[82] R. L. Hawkins, "PVA Corrugating Adhesives," Paperboard Packaging, 67+, June, 1963.

The major disadvantage of PVA adhesives is that they are not compatible with standard borax-caustic starch or dextrin adhesives. When in contact in even the smallest quantities, a rubbery gel is formed. This problem is compounded in that most polyvinyl acetate adhesives contain some polyvinyl alcohol.[83] This will be further discussed in the next chapter. Borax compatible resins have been developed by eliminating the PVA, but these are generally more expensive. These may in some cases, be added to dextrin adhesives to give increased water resistance and other properties. Resin adhesives may also be combined with each other; for instance, one with a high softening point may be used to increase the blocking temperatures of other emulsions.[84]

Polyvinyl acetate emulsions give excellent storage ability, shouldn't require any special mixing or heating and are considerably faster setting then dextrins. Furthermore, they will adhere to more difficult surfaces due to a better specific adhesion to these than dextrins and will, therefore, seal a wide variety of paperboards. This includes those with coatings or a dense overlay of ink such as Western Electric's Call Director cartons. Improved milage and reduced waste are also achieved. They are generally cleanable with water though the one tried in merchandise proved somewhat more difficult than the dextrin used

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[83] Dovris, Op. cit.

[84] "PVAc Emulsions for Adhesives," Op. cit.

previously.[85] Solvents or steam may sometimes be necessary once the film has dried.

They give outstanding final adhesion though the bond may degenerate some on aging due to oxidation. They have a good safety margin in the final strength of the bond and give the widest acceptable range over all significant sealing variables.

Specific Applications of Adhesive Analysis

The resin glue tested by the author in the merchandise area (see Chapter V) gave no failures. It illustrated a way to insure consistent results with a variety of carton finishes for $1,100 more per year in materials costs and probably $200 more for housekeeping. It should prove especially valuable in winter months when problems were at a peak in 1962 and 1963.

This would be much more important in a glue sealer in the central packing area since the number of suppliers is 10 or 12 rather than two or three at a given time, with an increase in variety of finishes somewhat smaller than this. A resin adhesive will widen the possibilities for future packs in regard to finishes, inking or most any coating considered. It will give a greater margin of safety in strength and better resistance to environmental conditions. It would cost about $1,700 more annually than a dextrin in central packing, but approximately $8,000 less than the present stitcher.

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[85] Asbury, Op. cit.

MERCHANDISE STUDY

Purpose

The author felt that he could not fully recommend a glue sealer unless he could obtain trouble-free performance on Western Electric's existing Standard-Knapp glue sealer (see Figure II) in its merchandise area. Sealing quality on the whole had been much better than with the stitcher, but there had been lapses in this good performance. A carton or two every few pallet loads would have flaps not sealed--usually the top flaps but sometimes the bottom or both. Since the palletizing was done automatically, if the man running the entire system was not in a position to see the carton or did not notice it, it would be palletized open. If the carton were one of the first in the lot this might mean hand unloading and reloading nearly an entire pallet to hand seal it. Even if the man did see it, it meant stopping the entire line and hand sealing the carton. Any line stoppage is costly and the operator had more important things to do. Therefore, a rather small irksome problem did have moderate economic overtones. According to several informal sources, the problem the previous winter had been much more serious. Whole loads had failed to seal, causing considerable down time and hand labor. No records had been kept

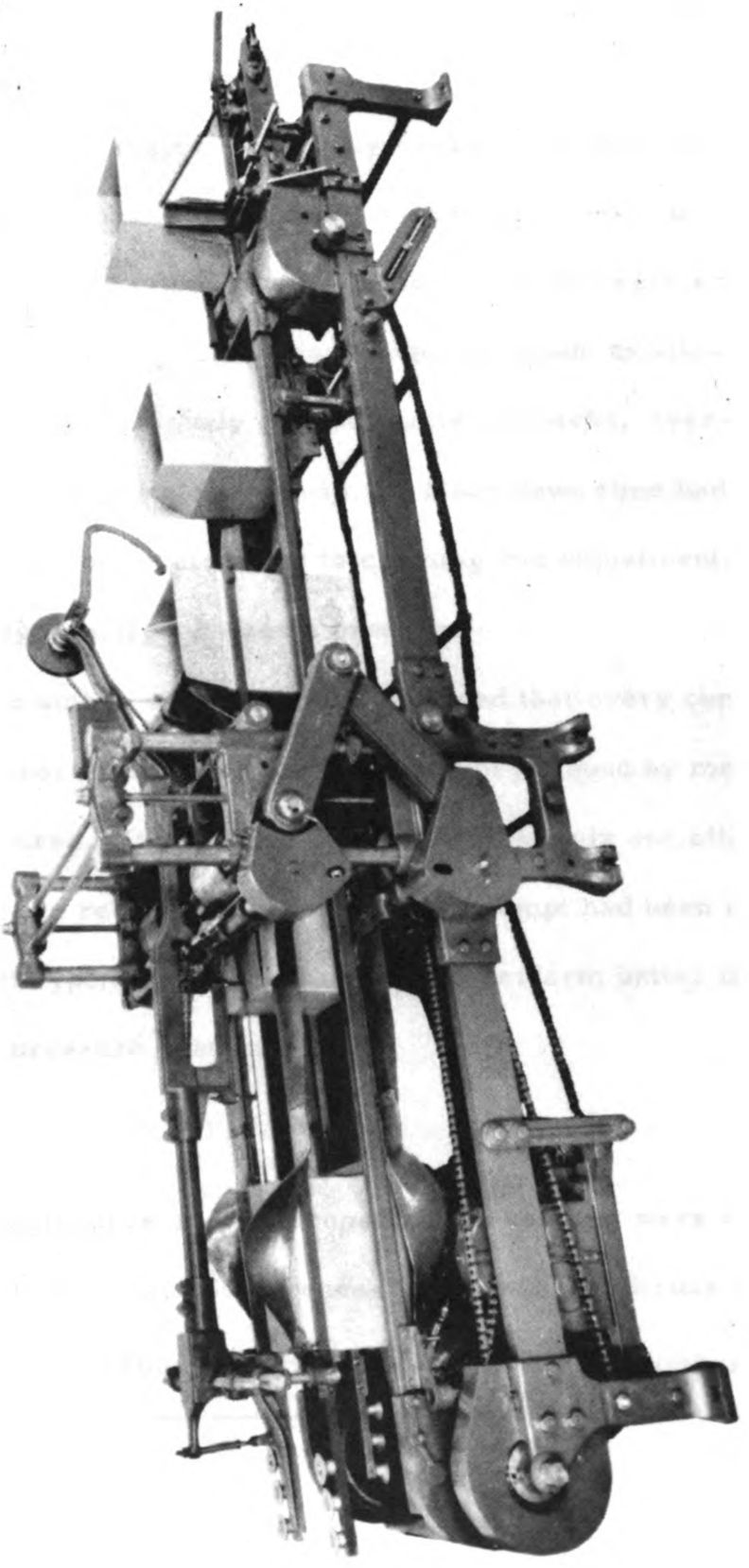

Figure 2.--Standard-Knapp glue sealer of the type used in the merchandise area of Western Electric's Indianapolis Works.

concerning the failures, but qualitative descriptions agreed results had been significantly worse.[86]

The glue sealer, originally used for all packing, was automated for just telephone set cartons in 1958 and moved to merchandise. A pressurized glue system was installed in 1962 to replace the previous pot and roller method. This change was made to allow more accurate glueing (previously glue had gotten in packs, over-glued them, etc.) and minimize clean-up.[87] Much down time had been incurred with the old system due to cleaning and adjustment, but flap opening had apparently not been a problem.

The author was originally informed that every conceivable glue type had been tried and "the best" had been found by men in the merchandise area. It was later discovered that only one other adhesive had been tried in recent years and that no attempt had been made to find if another type, or even viscosity, would perform better in conjunction with the pressure system.

Method

Maintenance and glue consumption records were checked as well as complaint files. Conferences were held with Bruce Robertson, Russ Dazey, Dick Asbury and Bill Miller[88] to piece together the history

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[86] Ibid.

[87] Robertson, Op. cit.

[88] William Miller, Chief of Machinists, Western Electric Company, Inc., Two discussions during July, 1963.

of modification, uses and performance prior to the author's arrival and under conditions not completely reproducible.

Several means of observing and recording variables under existing conditions and under experimentally induced changes were introduced. A weatherometer was placed in the vicinity of the glueing equipment to continuously record temperature and relative humidity. These were also specifically recorded in conjunction with top and bottom application pressure, time, and a qualitative and quantitative description of sealing results at random times each day. Application pressures were varied and results noted. Occasionally cartons were ripped open immediately after clearing the compression unit or after storage. In the latter case,attempts were made to check cases that had been stored under various loads (at different levels on pallets and on pallets stored at different levels).

The author was fortunate that during the dextrin observations one entire shipment of cartons from a small supplier refused to seal at all. Environmental and sealing conditions were essentially the same as in other periods and another shipment ran perfectly immediately with no other change. Samples were sent to Inland Container's labs for thorough analysis. The rest of the shipment was saved for subsequent testing with potential replacement adhesives. Observations were made using the borated dextrin for about six weeks.

The author conferred with a technical representative of National Starch[89] and decided on a predominantly polyvinyl acetate emulsion with which to conduct full scale production tests on telephone set cartons. Since the resin adhesive did contain some polyvinyl alcohol, it was not compatable with the borated dextrin. A thorough acid flush of all lines and parts in contact with the adhesive was, therefore, necessary. To minimize down time this was conducted by the maintenance department during the midnight shift when telephone set production was shut down. Four per cent acetic acid was used.

Data was taken and results were analyzed from the production situation in the same manner as had been used for the dextrin adhesive. Again, application pressures were varied in an attempt to find limits and cartons were checked randomly after sealing.

Besides normal merchandise cartons, small test runs were made using the most difficult sealing packs in the central packing area. These included Call Director cartons, completely covered with a dense ink overlay, and simulated bulk packs with no inner support.

Furthermore, the shipment of telephone set cartons that would not seal using the dextrin were put back in production using the resin.

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[89]Edward J. Payne , Technical Representative of National Starch and Chemical Company , Personal interviews on three different occasions between June and October, 1963.

Results

The author found no significant correlation of performance with temperature or relative humidity within the ranges of 70 to 88 degrees and 33 to 68% using either adhesive. This does not tell the whole story, and temperatures of 40 and 50 degrees might have adverse effects with the rest of the variables constant. This,theoretically,would be most detrimental using a dextrin adhesive which coincides with poor reported results during the preceeding winter.

Application pressure is an important variable as it governs directly the amount of adhesive applied. With the dextrin adhesive there was a narrow permissable range which was different from top to bottom heads, but was quite constant in each of these sets within the ranges of other variables encountered. Existing equipment was such that even this restrictive range (about 3 pounds) was relatively easy to meet.

As stated previously, occasional cartons did not seal and one shipment refused to seal at all using the dextrin glue, even with other conditions constant. It was discovered that the wayward shipment of cartons had been manufactured with normally easily sealable liners reversed to save the producers glue and trouble in the corrugating process. It was promised by the manufacturer that this would not happen again.

Probably the most significant variable outside of the basic type of adhesive was liner variation, especially its surface finish and

orientation. There are not industry-wide standards yet for corrugated liner finish as there are for chipboard containers. Specifications could be written using operational definitions, but as will be explained later, it may not be necessary-or advisable-for Western Electric to limit its suppliers in this way. The best results have been with a "water" finish-which utilizes steam and water in the calendering, but not starch-with the finished side of both liners away from the corrugating medium.

The actual switch to the resin adhesive proved a bit hectic. The flush was apparently not thorough enough and the rubbery gel that was forecast in that event surpassed all expectations. Considerable down time was incurred due to necessary purging of the glue lines. One mildly pleasant fact was noted in even this minor setback--the resultant gel was not particularly stubborn and resistant to clean up as the original adhesives had been in some cases. Its consistency could be compared to pie crust dough and it was neither slippery nor sticky.

Bonding results, as opposed to those of the transition, were without exception excellent along all variables. Absolutely no failures occured under any conditions when glue was actually applied to the flaps. Allowable application pressure variation was increased from 3 p.s.i. to over ten (and really, considerably more). The only way failure could be induced at the low end was to cut the pressure to a point where no adhesive was applied (about 3 p.s.i.). There was no down time on the line due to the adhesive, once the dextrin-resin change was completed.

Inked Call Director cartons with and without support sealed well with no failures. The stubborn shipment of cartons with the reversed liners, likewise, sealed with no exceptions. Bonds tested on recently sealed and stored cases were consistently stronger when sealed with the resin based product.

CONCLUSIONS

The author feels that the existing situation in Western Electric's central packing area is for the many reasons presented, completely unsatisfactory.

It is further felt that a glue sealer not only meets the needs of this area, but is far superior to other available case sealing methods.

Necessary steps should be taken toward acquisition of a suitable unit, starting with quote solicitation by the Indianapolis Works' purchasing department and meetings of manufacturers' representatives with men from Western Electric's purchasing, packaging engineering and central packing departments to finalize requirements.

Manufacturers that can supply units satisfying central packing requirements include Standard-Knapp (Emhart), ABC, and Fergusen. Others that might be investigated further are General Corrugated and Union Bag and Camp.

A random unit is not felt justified or even particularly advisable considering the central packing situation and the total system within which it operates. Presettability for the case size of the lot following that being run would be desirable, preferably controlled at the feeding area.

A pressure application system is recommended, preferably with cam action placement of heads and definitely one that will not dispense adhesive unless the machine is running and the heads are in contact with the carton flaps. This will allow one man to feed and control the machine when other labor demands make this temporarily advisable. Some sealer companies will install their own units and others will modify their machines with independently manufactured units such as Tru-Glu.

A resin adhesive is recommended to insure continuous positive sealing of the wide variety of cases and finishes in the central packing area. National Starch 33-1145, a polyvinyl acetate emulsion, was thoroughly tested in merchandise and should give excellent results in this area.

RECOMMENDATIONS FOR FURTHER STUDY AND ACTION

The viscosity, as well as other variables, can easily be altered by the manufacturer through the introduction of modifying ingredients as discussed in the glue analysis. A more viscous polyvinyl acetate emulsion should be investigated as it might well be advantageous. Housekeeping would be made easier since there would be less tendency for the glue to drip when lower heads are not tightly in contact with pads. Moreover, more accurate control of volume could be achieved allowing the corporation to reap the benefits of the small volume of this type of adhesive necessary for an excellent bond.

This was thought unadvisable until the value of the basic change could be clearly shown, but seems in order now. The experimentation would not require the thorough acid flush necessary to go from a borated dextrin to a resin and vice versa. Even though the acid is weak (about four per cent acetic) it is hard on machinery and should be used as few times as possible. Furthermore, the danger of downtime resulting from an incomplete flush would not be encountered.

The recording of environmental conditions and corresponding sealing results should be continued to discern any differences during winter and spring periods. If difficulties are encountered during lower

temperatures, several conditions may be altered. The drum may be heated mildly (70-80°F). Overdoing this may cause drying out of the adhesive or excessive penetration. A viscous adhesive should not be diluted as this will reduce the percentage of adhesive solids (which actually form the bond) and increase the amount of solvent that must leave before a bond is formed. Excessive agitation may introduce foam which also has the former effect.

If for any reason a dextrin is returned to, results could be improved by pre-heating the container flaps to help minimize setting time and reducing the pressure on the compression unit to help minimize excessive penetration. Neither of these measures should be necessary with a resin adhesive.

Specifications could be added to Western Electric's final carton requirements stating that liners must be finished with water and steam and possibly that the finished side is to be away from the corrugating medium on both liners. It might be further stipulated that starch or certain fillers not be used. This would require checking with suppliers to see which they could economically and readily vary. This would probably be unnecessary with a resin adhesive and it would be unadvisable to limit either suppliers or Western Electric's own future developments unnecessarily.

Warehouse checks should be made to determine resin bond strength loss after various periods of aging.

APPENDIX

Uniform and Consolidated Freight Classification

Section 7, Rule 41

Boxes must have both inner and outer flaps drawn together as closely as possible to insure a tight pack; lengthwise flaps must meet or overlap; no flaps must project over edges; and boxes must be sealed by one of the following methods:

1. All flaps must be firmly glued not less than 50% of area of contact.

2. All outer seams must be securely fastened with metal rivets, staples or stitches not more than 2 1/2 inches apart (see Note) but allowing sufficient space to remove stitching device and such rivets, staples, or stitches must be placed not more than 2 1/2 inches apart on each side of center seam but need only be used where outer flaps overlay inner flaps.

Note. Staples made of flat wire of hardness not less than equivalent of Rockwell B90, and not less than .037 inch thick and not less than .074 inch wide, with not less than 1 1/4 inch crown, may be spaced not more than 5 inches apart. Such staples may be used across center

where outside flaps meet, in lieu of on both sides of center seam but need only be used where outer flaps overlay inner flaps or

Stitches made of arcuate wire of hardness not less than equivalent of Rockwell B90, and not less than .027 inch think and not less than .095 inch wide, with not less than 1 inch crown, may be spaced not more than 5 inches apart. Such stitches when spaced not more than 2 1/2 inches apart may be used across center seam where outside flaps meet in lieu of on both sides of center seam, but need only be used where outside flaps overlay inner flaps.

3. All outer seams must be securely sealed full length with paper sealing strips. Paper sealing strips must be made of sulphate paper, and must conform to the following specifications:

Minimum Basis Weight of paper not gummed, 24 X 36 inches, 500 sheets Pounds	Minimum Tear Resistance		Minimum Tensile Strength Long Direction Pounds per inch width
	Long Direction Grams	Short Direction Grams	
60	113	134	45

or all outer seams must be securely sealed full length with paper sealing strips made of rope stock paper, basis weight after sizing and coating not less than 85 pounds, testing not less than 65 pounds, or of two thicknesses of sulphate paper, total basis weight not less than 60 pounds, and testing not less than 60 pounds, combined with waterproof adhesive and reinforced with glass fibres, distribution of fibres to give reinforcing in both cross and lengthwise directions, or reinforced with unspun sisal fibres not less than 13 to the inch running in lengthwise direction. Weight of glass fibres per ream of paper must not be less than 15 pounds. Sealing strips must not be less than 2 inches wide.

4. When tape conforming to the following specification is used, center seams only need be sealed. Tape must not be less than 3 inches wide and must extend over the ends not less than 2 1/2 inches.

Tape must be made of two sheets of sulphate kraft, each not less than 30 lbs. basis weight, reinforced with glass, sisal or rayon fibre, combined with a laminant of asphalt or other material not affected by temperature extremes any more than would standard 180° to 200° softening-point asphalt.

Tape must be reinforced by lengthwise fibres spaced not more than an average of 1/2 inch apart, and by crosswise fibres spaced not less than an average of 2 per inch except that when a diamond pattern is employed for crosswise reinforcement the spacing between the parallel sides of the diamond measured in the machine direction must not be more than 1 inch.

Glass or sisal reinforced tape must have a minimum tensile strength in the machine direction of 75 lbs. per inch of width and a mimimum tensile strength in the cross direction of 45 lbs. per inch of width; rayon reinforced tape must have a minimum tensile strength in the machine direction of 57 lbs. per inch of width and a minimum tensile strength in the cross direction of 27 lbs. per inch of width, with elongation not exceeding 15%. Tensile tests on the finished product shall be made on a three inch wide sample.

Tape must have a performance test not less than 35% greater than paper sealing tape applied in accordance with "3" above, when applied to 275 lbs. test box 24 x 12 x 12 inches loaded with filled No. 2 cans to gross weight of 90 lbs. and tested in a standard 7 foot revolving drum.

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