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MECHANIZED, NON-STOP RESIDENTIAL SOLID WASTE COLLECTION

William Da Vee, et al

City of Tolleson, Arizona

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ACKNOWLEDGEMENT

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Glen Myers and May Myers who manufactured the equipment and worked so faithfully toward revision and improvement and without whose genius and devotion the project would never have been accomplished.

Special acknowledgement goes to the Mayor and City Council, who have patiently dealt with complaints and who have had the fortitude to see the project through to the end, and especially to Mayor P. J. Green who has given his special support and advice on the work.

J. R. Green, Director of Public Works, and the members of his Department provided the necessary training, conducted surveys, and made installations of equipment on a timely basis. Esther Angulo, City Clerk, and the members of her staff made difficult Spanish translations for our surveys and public information in addition to the many clerical duties connected with the project.

Finally, the people of Tolleson accepted the system and its installation along with the early problems and inconveniences. They are citizens who are willing to experiment and deserve our sincere thanks for their cooperation.

--- William DaVee
City Manager
Tolleson, Arizona

MECHANIZED NON-STOP RESIDENTIAL
SOLID WASTE COLLECTION

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MECHANIZED, NON-STOP RESIDENTIAL SOLID WASTE COLLECTION

SUMMARY

This report describes the development of a non-stop, one-man refuse collection operation that is five times as productive as the old conventional rear loader collection system it replaces.

Tolleson has worked to demonstrate the system using funds from a Federal demonstration grant administered by the Office of Solid Waste Management Programs of the U. S. Environmental Protection Agency.

The work was accomplished in three phases. Phase I demonstrated that the concept of non-stop collection was feasible and could be mechanized successfully. Refuse was collected from eight households using the standard 55 gallon drum containers suspended from a stand in the alley behind the homes. Improvements were made to the stands and the dumping mechanization.

Phase II developed a non-stop prototype truck, installed an alley of 53 containers and demonstrated the use of the new truck in the alley. The truck with its original bumper arrangement failed to collect the solid waste completely due to problems of surface condition, container placement and collection speed which could not be solved without substantial installation cost increases.

An alternative method of collection, utilizing a guide rail arrangement with a roller on the container, was proposed by the inventor and installed. The guide rail system produced impressive results emptying all containers with no litter problem.

In Phase III, the non-stop collection system was implemented on a city-wide basis. A total of 868 containers were installed. The new method of collection demonstrated a perfect safety record in one of the most dangerous industries in the United States. Implementation of the system city-wide was accompanied by a general clean up of alleys by homeowners. The improved appearance has remained in the alleys for over a year and can be expected to continue.

An attitude survey of system users demonstrated strong citizen support for mechanization. Nearly ninety-nine percent of those surveyed felt non-stop collection is an improvement over the rear end loader method of collection.

The analysis of the economics and productivity of non-stop collection demonstrates that it is an attractive alternative to the rear end loader. In terms of productivity, one man was serving the entire community with service three times per week in 88 hours per month. The rear end loader, with a crew of three, needed 99 hours per month or 297 man hours to provide twice a week service.

The cost per dwelling unit per month totalled $1.80 for the rear end loader system and only $1.14 per dwelling unit per month for the non-stop truck. The City of Tolleson is saving $.66 per dwelling unit per month through use of non-stop collection. When multiplied by the number of dwelling units, this savings is substantial even for a small community such as Tolleson.

In summary, the non-stop collection system demonstrated in this project could save communities throughout the United States thousands of tax dollars. It employs relatively simple equipment, is amazingly productive and offers a better working environment for the solid waste collector. The system can now be purchased from Bionomics International, Phoenix, Arizona.

INTRODUCTION

Refuse collection in the southwest United States has a long history. Until the 1600's, prehistoric Indians and their descendants disposed of refuse by throwing it in piles called trash mounds, near their homes. These trash mounds are now excavated by archeologists and provide a great wealth of information about these people.

Later, the area became populated by settlers and towns and cities began to appear. This urbanization brought about the need for better methods of refuse collection and communities responded by creating specialized "sanitation" departments. The equipment used by these agencies consisted initially of hand carts and horse drawn wagons. Later, with the advent of the internal combustion engine, trucks were employed in the effort to collect the increasing volumes of refuse.

A major breakthrough was achieved when a vehicle was disigned which loaded from the rear and compacted the refuse as it was loaded. This truck is called a rear end loader and has served as the mainstay of refuse collection for a number of years. (Illustration 1).

This report presents an analysis of a new type of vehicle that makes the rear end loader method of collection comparatively expensive for several reasons.

First, the rear end loader system relies heavily on manual labor with two and frequently three employees required. One employee serves as the vehicle's operator and normally does not collect containers as they must be dumped into the rear of the vehicle. Two workman do the collecting, lifting the containers, dumping them into the hopper, and returning the containers to their original location. When the hopper is full, a ram is activated, the refuse is cleared from the hopper and is compacted into the body of the truck.

Three employees must be paid in this system for all hours on the job including trips to the disposal site when two of the three are not engaged productively. They are simply riding and waiting for the truck to return to the collection route.

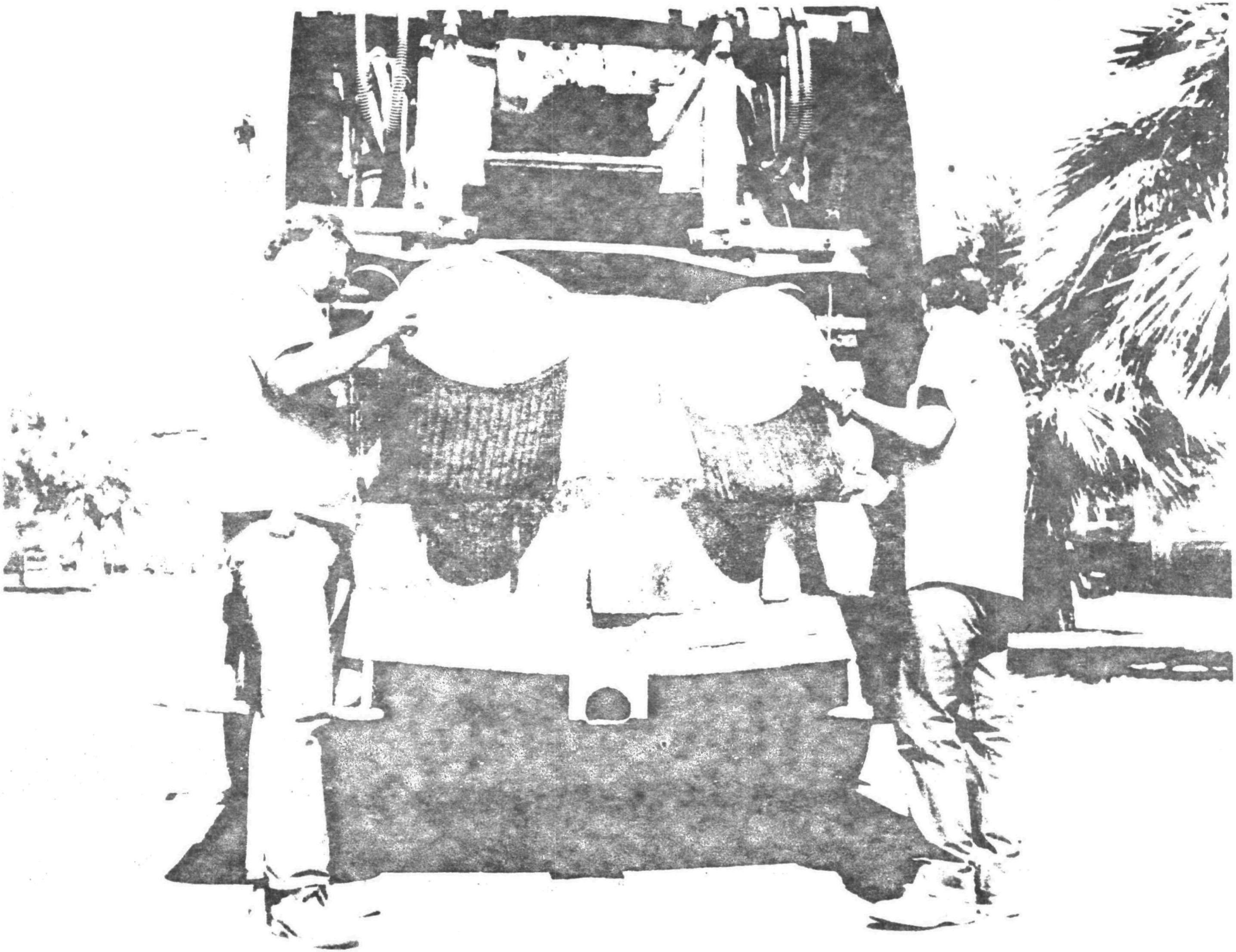
A second characteristic of the rear end loader system is that the job of collector requires considerable physical exertion. New York City reports that to load 8,100 pounds of refuse daily, the average collector carries 3,000 pounds of containers to and from the truck. Although this problem has been somewhat alleviated with the introduction of light plastic bags, the collector still lifts the refuse itself from the ground to the hopper.

In addition to being strenuous, the job of refuse collector is dangerous. In 1970, the frequency rate of disabling injuries for the waste collection industry was 90.90 losttime injuries per million man hours worked. Comparing this rate with the rate for policemen, 53.24 in 1968-70 and for logging, 19.96 in 1968-70, refuse collection stands out as a hazardous profession. Some of this problem can certainly be attributed to the lower quality and work habits

ILLUSTRATION 1

A REAR END LOADER COLLECTION VEHICLE

A conventional rear end loader manned by a typical three man crew was used in Tolleson prior to this demonstration.



of refuse collection laborers, but the continual stop and go movement, the physical exertion of the truck, of handling varying sizes and weights of containers, and the general work environment remain the dominant reasons for the high accident rate.

Combining high labor costs, the physical exertion required, unsafe working conditions and, in the case of the community where this demonstration project occurred, summer temperatures in excess of 100 degrees, it is easy to understand why willing workers are difficult to find. Yet most of these problems are faced every day by communities throughout the United States.

What can be done? This report represents a joint effort by the City of Tolleson, Arizona and the Environmental Protection Agency to solve these problems through mechanization of refuse collection.

Historical Background

Tolleson is one of a number of cities concerned with the many problems and particularly with the rising costs and labor requirements of its refuse collection service. Shortly after he was appointed City Manager in 1969, Bill Da Vee recognized the need to improve collection methods.

Mr. Da Vee was contacted by Mr. Marcel G. Stragier, Public Works Director of Scottsdale, Arizona, who suggested that the City of Tolleson investigate a new method of refuse collection conceived by Mr. Glenn Myers, a Phoenix inventor. Mr. Meyers proposed a non stop collection system which consists of a specially designed truck and container. Containers are mounted on poles and are turned over and emptied by the truck without stopping at each container. Only one employee is used to operate the truck.

In order to develop the Tolleson City Council's interest in the system, a simple demonstration of the concept of non stop collection was held on September 19, 1970. A bracket was installed on a utility pole in an alley, a 55 gallon drum was mounted on the bracket, and a truck was modified with a rubber tire and sheet metal tray on its side. (Illustration 2). Various types of refuse were placed in the container and emptied into the tray on the truck. The container was successfully emptied while the truck proceeded ahead non stop. The truck merely bumped the container with the soft rubber wheel, to swing it around the bracket. Refuse fell into the tray.

After viewing the demonstration, the Tolleson City Council was satisfied that the demonstration adequately demonstrated the potential of the system and Mr. Da Vee was authorized to seek federal assistance to demonstrate non stop collection. Mr. Stragier's private firm, Government Innovators, was employed by the Tolleson Council to assist in the project from application through project completion. An application was subsequently filed with the Environmental Protection Agency and approved for funding.

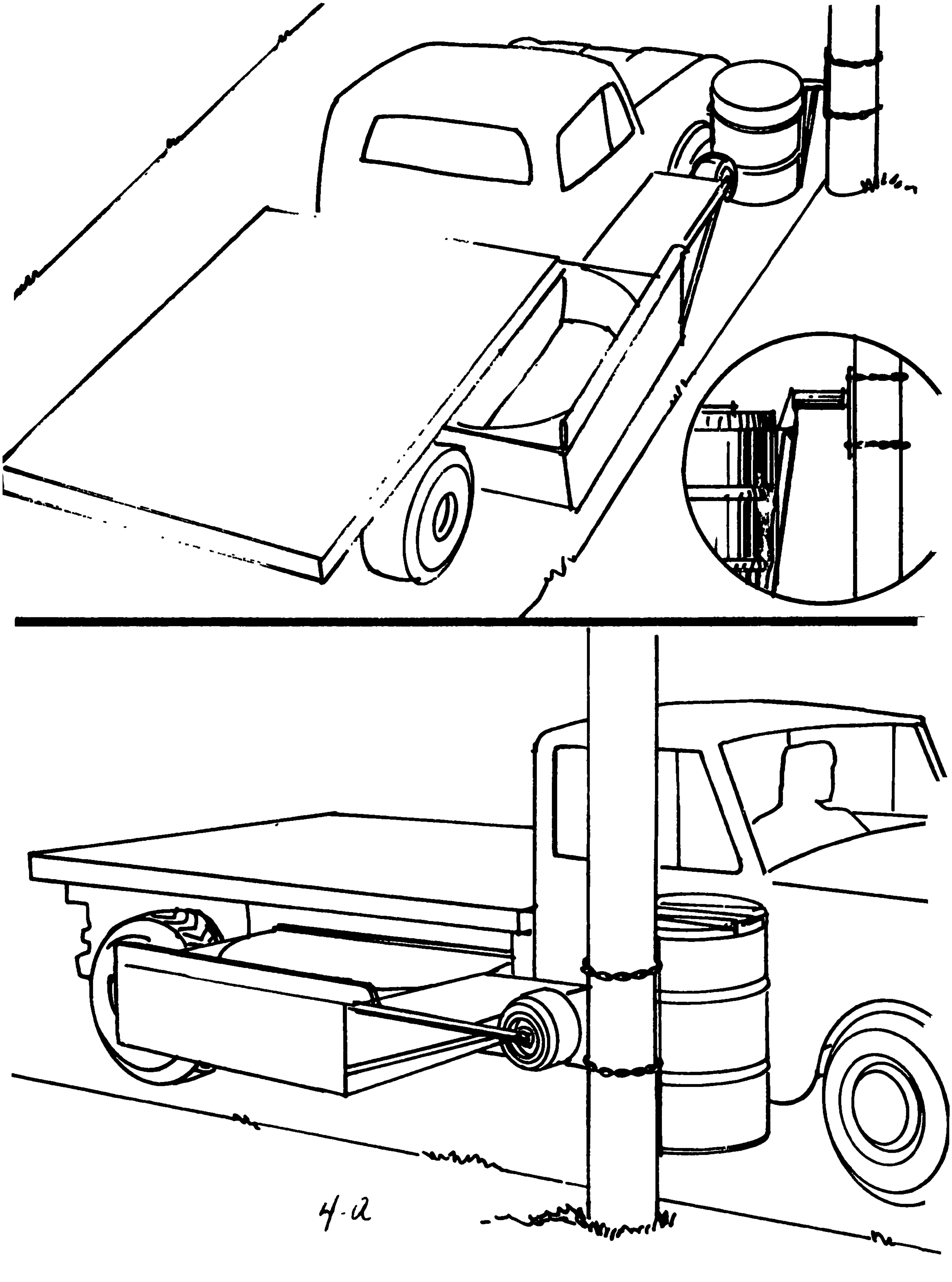
Study Area Characteristics

The population of the City of Tolleson in the 1970 census was 3,881 but now approaches 4,000 with recent building and an annexation. According to the 1970 census, the median shcool years completed was 7.9 and the percent of the population completing four years of high school or more was 21.3. The unemployment rate in

ILLUSTRATION 2

NON STOP COLLECTION DEMONSTRATION

To demonstrate the concept, a bracket was installed on a utility pole in an alley, a 55 gallon drum was mounted on it, and a truck was modified with a rubber tire and sheet metal tray.



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1970 was 4.6% with the median income at $6,260 per year. Twenty-six and one tenth percent of the population had an income less than the poverty level in 1970.

The City of Tolleson is located ten miles west of downtown Phoenix. It has a sunny, dry climate with mild winters. The average maximum temperature for the year is 84.7°F with an average minimum of 53.3° and an average rainfall of 7.2 inches. Sunshine is expected on an average of 86 percent of the days during a year. The climate is favorable for refuse collection during most of the year. During the summer, however, temperatures exceed 100°F and make refuse collection a difficult task for collection crews which must work in the open.

The terrain of the City of Tolleson is flat. The 12.25 miles of streets in the community are laid out in a grid pattern. There are 6.37 miles of alleys. In summary, the topographical characteristics, street and alley system and climate of Tolleson provide an ideal location for demonstration of the non stop collection system.

Refuse Collection Services in Tolleson

Tolleson has a Council-Manager form of government. The City Manager is the executive head of the organization. Reporting to the City Manager, the Public Works Director supervises a range of activities including refuse collection.

The refuse collection program consists of three operations. The first is the non stop mechanized collection system which services all single family households in Tolleson. This activity involves the non stop collection vehicle, a driver, and occasionally some part-time assistance to install and repair containers and provide routine maintenance service on the non stop truck. Normally, collection service requires about 20 manhours per week and collects about half of the city's waste.

The second refuse collection activity is commercial service and consists of pickup of 28 commercial accounts by the rear end loader with a crew of three men. Refuse is collected from one and two yard containers. The customers include schools, businesses and other institutions. Because several of Tolleson's business establishments involve agricultural and meat production, service must be provided on a daily basis to avoid the creation of unsanitary conditions.

The 55 gallon container developed in the experiment for the non stop system cannot contain branches, wood, pieces of furniture or other large objects. For this reason, the city provides bulk waste service on a once every two weeks basis. A crew and the rear end loader collection vehicle or a dump truck are used to collect these materials. Householders place their waste on the opposite side of the alley from the 55 gallon containers, or, if they do not have alley collection, at the curb.

Project Objectives

The general objective of the experiment was to demonstrate a productive, economical, mechanized system of refuse collection that provides for the collection of refuse from a multitude of small generators with a minimum of manpower. Under this general objective, the project proposed to demonstrate that refuse in Tolleson could be collected without manual handling of containers, that a collection vehicle could be designed which would not have to stop at every container, that the truck could be operated by one man who would not have to leave the cab and, finally, that the whole system would be less expensive to operate than the convention method of collection with the rear end loader. The project was divided into three phases designed in a logical way to develop the revolutionary system.

Phase I demonstrated the feasibility of non stop collection. Eight especially designed containers were installed and emptied by a bumper into a hopper arrangement mounted on a truck. The bumper and containers were studied for improvement.

Phase II developed a non stop prototype collection vehicle, installed a test alley of 53 containers and documented the results of the test operation.

Phase III was the city-wide implementation of the non stop collection system utilizing the truck and containers developed in Phases I and II. The system was studied for economics, and user acceptance.

PHASE I
PROJECT MANAGEMENT AND DEVELOPMENT

The objective of Phase I was to determine the feasibility of non stop refuse collection. To accomplish this objective, a non stop collection truck had to be acquired and a suitable container had to be constructed.

The eight original containers were purchased and assembled in accordance with design criteria established prior to the demonstration. The container consisted of a 55 gallon drum. In the Phoenix area, these drums can be purchased and delivered for a cost of $3.00 each. Each container was furnished with a metal lid which was attached to the container by a hinge. (Illustration 3). The drum was fastened into a framework which was attached to the pivot arm. The framework was designed to hold the container in place and transfer the impact of the bumper, which was used to invert the container. The pivot arm was horizontal, perpendicular to the path of the collection vehicle and attached to a vertical support. The vertical support was imbedded in concrete and was one foot from the container to give clearance for the truck receiving hopper.

The truck used in Phase I was a three quarter ton stake bed pick up. A soft rubber tire was attached to the front bumper and arranged to be retracted. A similar tire was mounted on the rear of the truck. A steel tray about 9 feet long by one and one-half feet deep and extending three feet from the side of the truck was installed to receive the refuse. Although the inventor's plan for the vehicle included hydraulic rams to clear the hopper, a canvas cover was used in Phase I by placing it in the tray to hold the refuse. When filled, the canvas was lifted out of the tray and the refuse was deposited in the rear end loader.

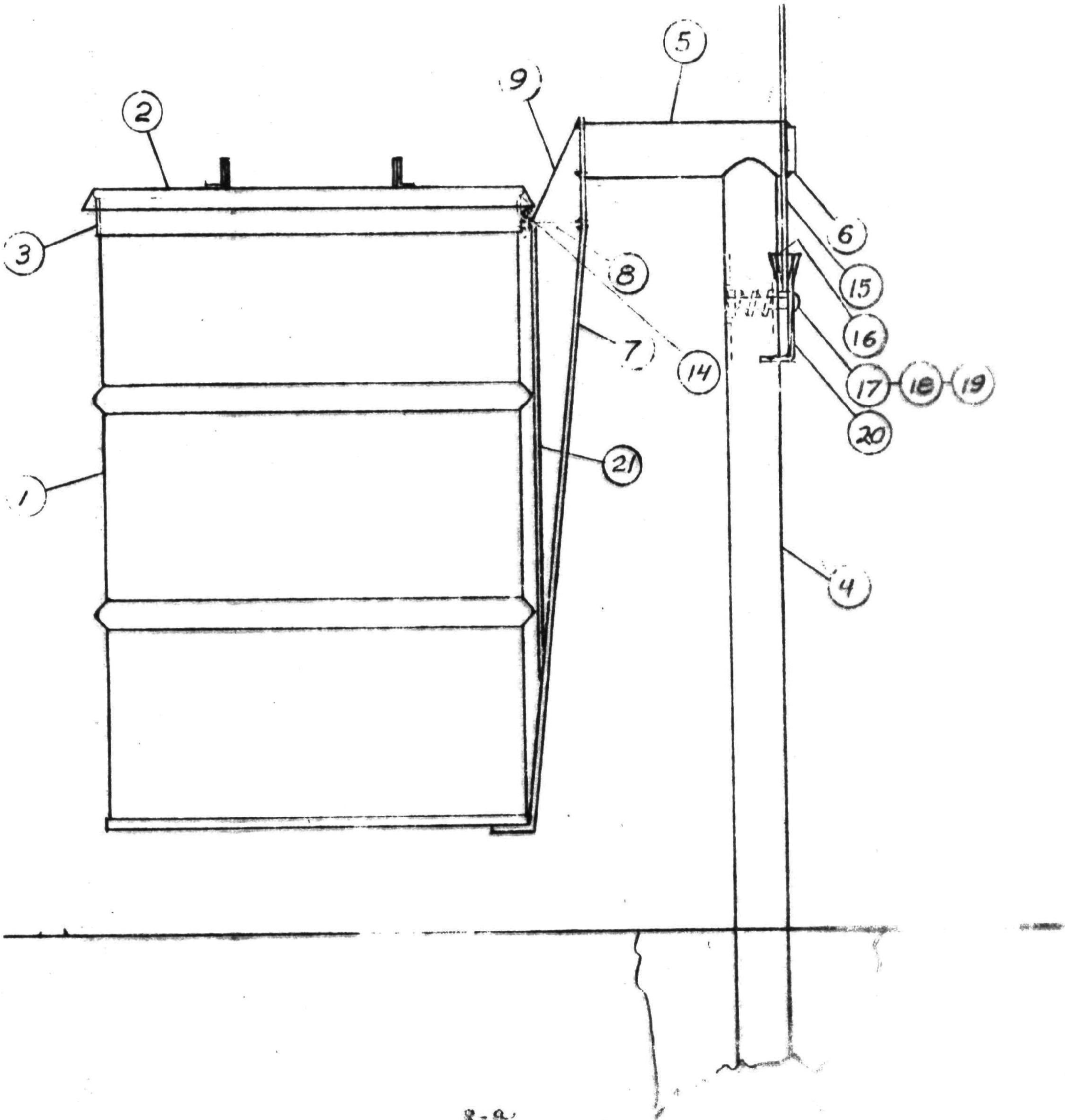
The truck and container were designed to work as follows: The vehicle proceeded down the alley at about six miles per hour. Containers and their supports were all placed on one side of the alley. As the truck moved ahead, the soft tire on the front bumper contacted the first container, pushed it away, up and around the pivot arm to a vertical, upside down position against a stop. Refuse spilled out into the tray. As the vehicle proceeded ahead, the second tire bumped the container back to its original position right side up.

In order to install containers, holes eight to twelve inches across and three feet deep were dug five feet apart near the property line along the test alley. Although near the property line, container installations were completely in the alley easement dedicated to the city. It was possible to locate each container near the back gate of each lot in this fashion. Some holes were dug for six inches of concrete and some were dug to allow for ten inches. A pre-mix concrete was used because of the small quantity involved.

ILLUSTRATION 3

BASIC PHASE I CONTAINER

Containers are held in place by the framework and swing around the pivot arm near the top when hit by the bumper.



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The crew initially had some difficulty in leveling the containers, but with each installation became more skilled. The containers were blocked up to a level nine inches from the ground and secured against any possible movement until the concrete set. The metal posts were equipped with cross pieces imbedded in the concrete designed to prevent the post from turning under stress. The crew required four hours to install the first two containers, and three hours to install the remaining four.

The initial test runs were made with the containers empty. In these test runs, the containers demonstrated a tendency to swing freely toward each other after the dumping cycle causing them to bang together at the bottom. These collisions resulted in serious denting of the containers. The rear bumper wheel was adjusted both up and down and forward and back, which had some beneficial effect, but failed to completely solve the problem. At the same time as the adjustments to the rear bumper were made, the front impact wheel was changed to different positions. After trying all the combinations, the banging was not completely stopped, but considerable progress was made in reducing the force with which the containers met. Finally, a shock absorber was mounted on the rear impact wheel to reduce the bouncing effect caused by the container hitting the rear wheel and a rubber drag was designed and installed to slow down the decent of the containers. The modifications were tested and found to eliminate the problem of the containers hitting together after the emptying cycle.

The dumping process of non stop collection remained loud even after the problem of banging the containers was solved. Observation of dumping through the use of motion pictures revealed that the lids were striking the metal portions of the collection bin. A rubber pad was installed in the front portion of the collection bin. This pad reduced the noise considerably and has become standard on the truck. Tests using a plastic lid were scheduled but the plastic could not withstand the punishment of dumping and, compared to the metal lid, was expensive to fabricate.

The collection vehicle was operated at various speeds to determine the optimum pace for the collection system. At six miles per hour the containers dumped properly. All lids closed, all refuse fell into the side bin at the desirable point and no containers struck each other after the dump cycle.

At 5.6 miles per hour, two of the containers came down prematurely during the dump cycle causing them to strike the collection bin instead of the rear impact wheel or the rubber drag.

At speeds in excess of six miles per hour, the force of the bumper hitting the container would cause them to bounce back from the stop device and land in the hopper. This action caused damage to the containers.

The driver was able to master the collection process quickly at six miles per hour. The speed was slow enough to allow him to be accurate in bumping the containers at the proper place. A new driver was introduced to the system and he too, was able to operate the truck properly after a few trial runs at this speed.

After these initial experimentations, the point was reached when actual collection could begin. A short letter was prepared and delivered to each residence by a city employee. (Appendix A). The letter stated that the neighborhood had been selected to receive the new collection service, gave directions on the proper use of the container, listed collection days (Monday, Wednesday, Friday) and encouraged the resident to contact the city manager concerning problems or suggestions. The city employee reviewed the letter with each family, answered their questions and left the letter with them.

Pick-up of all eight containers was implemented on a three days per week basis. During several of the pick-ups, there was high wind. Small amounts of refuse were blown from the bin but the amount was less than what would have fallen out if a rear end loader were used. The containers averaged about two thirds full during this testing period. The existence of excess capacity indicated that the residents were receiving adequate storage capacity.

The Health Department examined the containers after they were in service for a few weeks and could find no health related problems.

Conclusion

Phase I demonstrated that the containers would work. The bumper system proved satisfactory. Minor improvements were made to container brackets, handling and to accommodate dumping. Householders used the containers properly and demonstrated the feasibility of their use throughout the community. With the principle of non-stop collection successfully demonstrated, the experiment was ready to move into Phase II.

PHASE II

The objective of Phase II was to construct the prototype non-stop collection vehicle and demonstrate its operation in an alley of fifty-three containers. The performance of the vehicle and containers was to be documented and, if the test alley collection proved to be successful, the experiment would move into Phase III, city-wide, non-stop collection.

Phase II Implementation

Originally, a twenty cubic yard collection vehicle was to be used as the prototype. Since it would have required several months to build, the immediate purchase of a twelve cubic yard collection vehicle, built from the truck used in Phase I was recommended. (Illustration Number 4). The smaller truck was less expensive and, because of its size, faster and more maneuverable. This proposal was approved and the inventor's vehicle was purchased for $13,200. It was equipped with the bumper wheel, the receiving hopper and the shock absorber system to restrain the containers as they complete the dumping cycle. The receiving hopper was equipped with a mechanical arm to move refuse into the compaction chamber.

From our observations in Phase I and II, we identified the following variables that effect non-stop collection with the bumper system:

1. Mounting height of the container. Phase I demonstrated that a height from the ground to the bottom of the container should be approximately nine inches. This height provided for loading, kept the container clear of the ground and worked with bumper, hopper and stand.

2. Location of impact of the bumper. The bumper ideally should hit in the middle third on the vertical face of the container to accomplish proper dumping.

3. Speed of the collection vehicle. A speed of approximately six miles per hour worked best. Higher speeds left litter; lower speeds failed to invert containers.

4. Inertia of the loaded container. The inertia of the loaded container combined with the other factors was important in the dumping process. The container hit a stop when inverted and would damage the support if it hit too hard.

5. Spacing between containers. A set distance is preferable as it allows proper dumping, load transfer and compaction if the driver is operating the truck at the appropriate speed. Minimum spacing was about four feet. Truck speed varied depending on weight and spacing of containers.

6. Condition of the roadway surface. The condition of the surface was extremely important as it determined the point of impact and the maximum speed of operation. Potholes slowed the truck and often moved the bumper out of the target area.

ILLUSTRATION NUMBER 4

THE BUMPER WHEEL ARRANGEMENT

The truck used in Phase II was a proto-type constructed on a Chevrolet chasis. The truck operated at speeds which caused the containers to invert. After the refuse had dropped into the hopper, the container was bumped back into place by a wheel at the rear of the truck.

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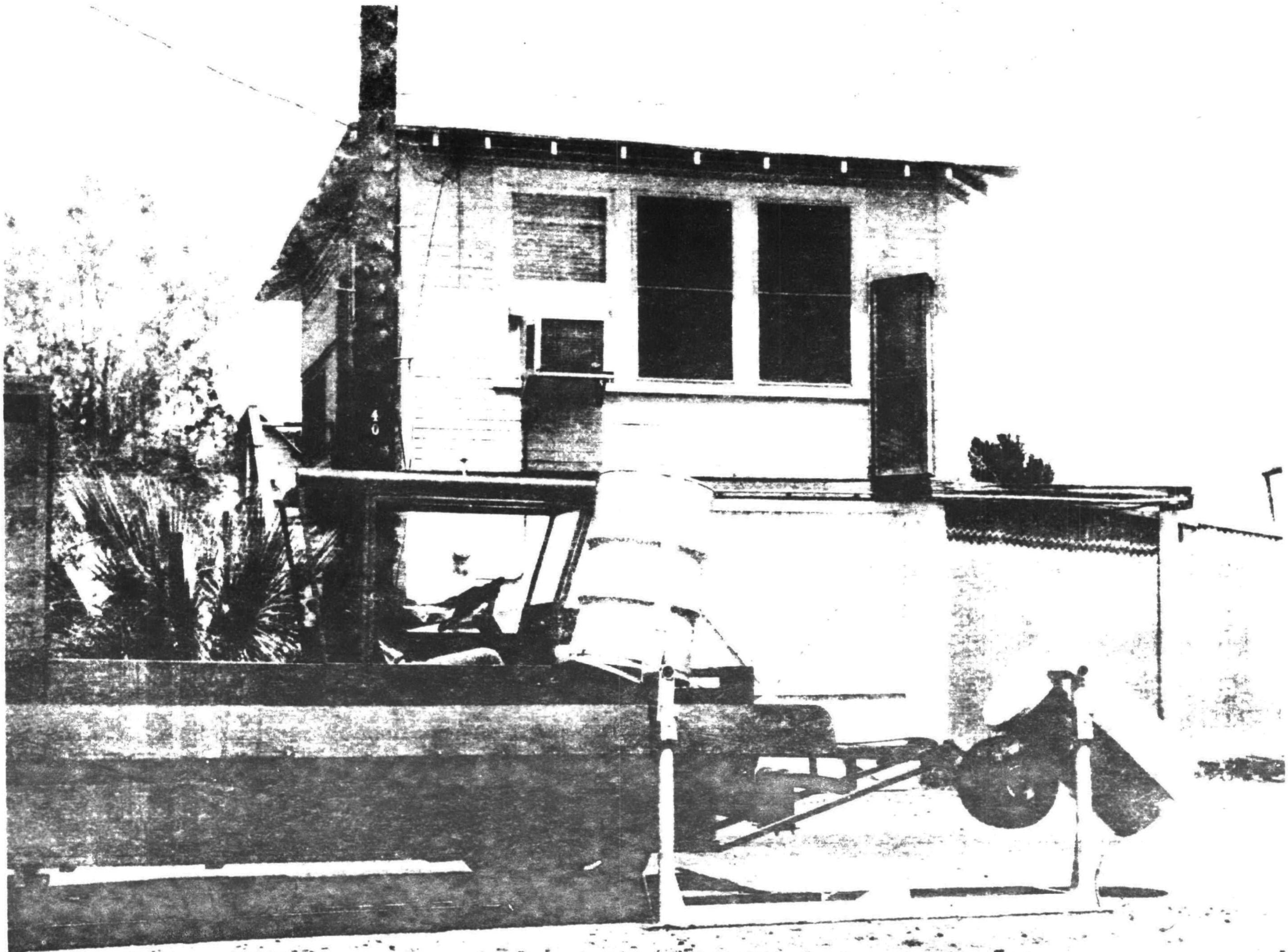


Recognizing these variables, every attempt was made to prepare the Phase II alley for the new collection method. It should be mentioned, however, that the alley was not paved, the lots adjoining the alley were narrow, some contained several dwellings, and there were dwelling units on both sides.

Instead of paving, the alley was graded at a cost of $152.00 including labor and equipment rental.

Fifty-three containers and container brackets were purchased at a cost of $1,325.00 and installed at fifty-three residences on the alley. City crews used rented digging equipment to accomplish the installation at a rental cost of $55.00. Materials cost $26.50 and labor expense was $231.00 for sixty-six man hours. The total cost of grading the alley and purchasing and installing the containers was $1,789.50 or $33.76 per container.

The containers were located on one side of the alley to accommodate the gates and paths of the users. Residents were given the same letter used in Phase I explaining the experiment and their role in it and each home was visited by a city employee to answer any questions on the new collection system.

Several trial runs were made with the twelve cubic yard collection vehicle. It was evident after these runs that the installation of the fifty-three containers and the reconditioning of the alley surface was not accomplished in accordance with the variables previously discussed. The alley itself served narrow lots. Mounting height varied, containers were not spaced evenly and the alley surface was not even because it was graded and not paved.

In Phase I, conditions were ideal for the bumper method of collection. The alley was paved, containers were evenly spaced instead of spaced to accommodate users and containers were exactly nine inches from the alley surface. The collection vehicle during Phase I was able to operate at a uniform speed, free of bumps and jolts, impacted containers at the same location, and dumped them successfully.

In the initial runs of Phase II, one out of ten containers did not properly complete the dumping cycle. Either they did not fully invert and lock in place because the bumper did not impact them with enough force or they inverted hard and bounced back because the pumper hit them with too much force. In either case, the container fell into the loading tray jamming the arm that forced the refuse from the tray into the compaction chamber. Several times during the testing the bracket which fastens the horizontal arm to the container was twisted.

The varying height and location of containers and the irregular alley surface demanded more driving skills than the vehicle operator could provide. Although he was able to improve in negotiating the varying mounting height, surfact textures, load weights, hydraulic system demands, and quick stops to avoid damage, containers continued to become caught in the hopper.

It became clear that effective use of the bumper method of collection was dependent on well surfaced alleys, uniform container installation and balanced loads. These factors could raise the cost of non-stop collection and make it uneconomical.

The inventor proposed a new method which involved the installation of a small roller on the outside bottom corner of each container and a guide rail along the side of the collection vehicle. Instead of inverting the containers by bumping them with the bumper wheel, the container would be inverted by running the roller along the rail which would guide it through the dumping cycle. The idea was tried at the inventor's shop and worked. It gave the operator a good deal more control, was simple and reduced litter because it operated at a slower speed.

Because of this successful shop demonstration, rollers were installed on all test alley containers and the guide rail was mounted on the prototype non-stop truck. (Illustration Number 5).

The guide rail system worked better than expected. The driver found that it was easy to line the rail up with the rollers on the containers. The system worked at varying speeds and was more tolerant to varying container heights, surface conditions, and loads in containers. After several runs, the driver became very proficient. The smoothness of the operation helped eliminate the litter problem encountered in the bumper method. With a major problem successfully solved, the experiment could proceed.

Residents were quick to utilize the containers which were provided. Those that were required to walk across the alley to deposit their refuse did so willingly.

Large cardboard boxes were difficult for the packer to handle as they would become jammed in the opening between the tray and body. Unusually large numbers of these caused delays and sometimes spilled out of the hopper. This problem was solved by asking residents to cut up the large boxes before depositing them in their containers. Thos who did not break up the corrugated boxes used them to contain the bulk rubbish collected separately.

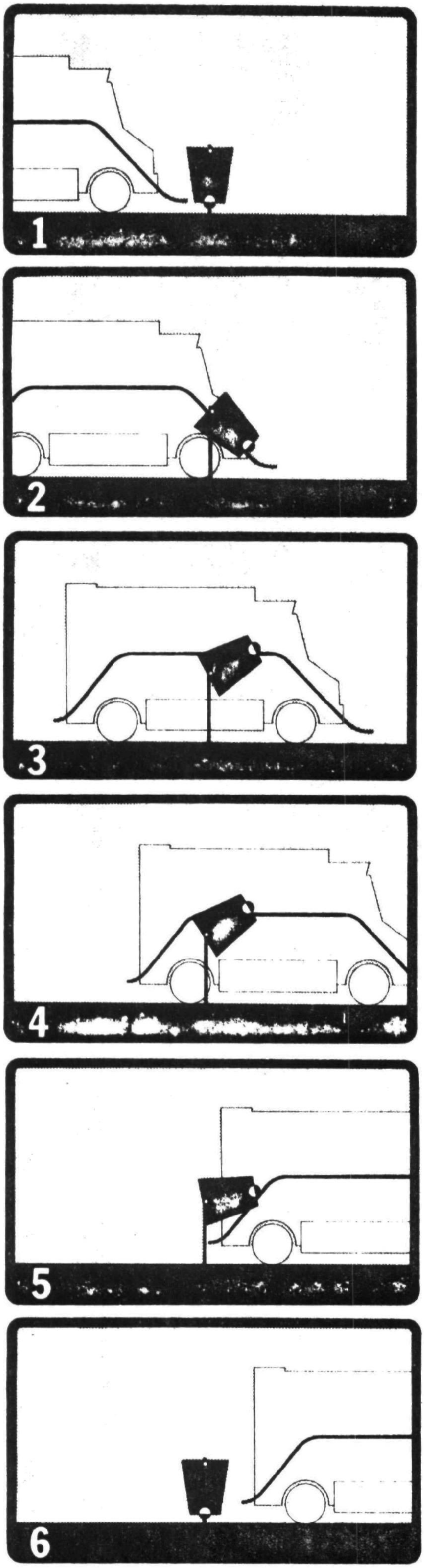
Since the bumper method of collection relied so heavily on proper surfacing and container height and location, analysis of the guide rail method was emphasized in Phase II. The vehicle's driver was trained to record the proper collection data.

The non-stop truck required an average of 9.2 minutes to collect refuse from the fifty-three containers in the alley. This figure represents a collection rate of 5.8 homes per minute or 348 homes per hour. The most time required to collect the entire alley was 20 minutes when the truck's hopper was jammed and the least time required was six minutes.

The maximum weight picked up in one collection was 1,840 pounds on a Monday. The average weight per container per collection was 20.9 pounds or 8.9 pounds per home per day and the per capita generation was 1.6 pounds per day.

ILLUSTRATION 5

During Phase II, a guide rail was installed as an alternative method of inverting containers. It slowed the non-stop collection truck but was much more dependable and production increased. The operating sequence is shown in this illustration.



OPERATING SEQUENCE

The illustrations at the left show a pickup cycle of the One-Man Nonstop Collection System.

As the truck approaches the container (Figure 1), the driver aligns the truck's rail with the spool mounted on the lower side of the container. The spool rides up the truck-mounted rail (Figure 2), pivoting the container on its pivot pin near the top of the post.

The cam action of the rail is designed so that the container is in the dumping position as the receiving tray passes benetah it (Figure 3).

As the truck continues on, the now-empty container clears the tray and is passed toward the rear of the truck (Figure 4).

The truck's forward motion causes the container to start its descent to its original position as the spool rides the downward portion of the rail (Figure 5).

The truck having emptied and disengaged the container, moves to the next container (Figure 6).

Since collection in Phase II was from only one alley, a cost analysis was not conducted. It was felt that the analysis of City-wide collection would provide much more meaningful results as the truck, driver, and containers would be in full use under actual and not experimental collection conditions.

Conclusions

Phase II objectives were successfully attained. The non-stop truck was purchased and demonstrated in an alley of fifty three containers. The truck with its original bumper arrangement failed to collect the solid waste completely due to problems of surface condition, container placement and collection speed which could not be solved without substantial installation cost increases. The bumper system was fast with the truck collecting at six miles per hours, but its limitations reduced its productivity to less than that of the guide rail system. An alternative method of collection, utilizing a guide rail arrangement with rollers on the container, was proposed by the inventor and installed. The new arrangement produced impressive results emptying all containers with no litter problem. The truck with rail could empty an average of 5.8 homes per minute and serve the entire alley of fifty-three containers in an average of 9.2 minutes.

With the successful demonstration of the non-stop truck in an alley of 53 containers, the experiment was ready for testing of the system on a large scale. In January of 1972, Tolleson embarked on PHase III, City wide implementation.

PHASE III

Phase I and II had shown that the non-stop refuse collection method was feasible and might produce substantial savings to the public. The system had been introduced successfully in alleys with 8 containers using the bumper method and then fifty three containers using the guide rail dumping arrangement. The question remained as to the economics of this new concept in refuse collection and its possibilities on a large scale away from highly controlled experimental conditions.

The objective of Phase III was to install and service containers at all residences in the city. The rate of installation of containers was projected at approximately one hundred containers per week and a crew of six city employees, who made all installations, were able to keep that pace. Final installations were made during the week of January 20, 1972, although adjustments and additional installations to new households have been made as required since that date.

A total of 868 containers were installed during this period including eighty-six at homes which required curbside service. Installation required 976 hours of labor at a cost of $3,414.50. This represents a labor cost of $3.50 per hour, including fringe benefits. Sand, rock and cement cost $279.00 and equipmental rental for a post hole digger, back hoe and cement mixer totaled $712.25. The installation cost per container for 368 containers averaged $5.07. The containers and brackets cost $17,360 or $20.00 each.

Curbside Installations

Refuse collections in Tolleson was made primarily from alleys and containers were installed as described in Phase II. However, eighty-four homes or 9.6 percent of the total number of homes required curbside collection. Collection service at the curb was provided during Phase III through the use of three different container designs.

First, 64 containers were installed on temporary stands. These stands were not set into the ground, but were installed in pairs using a metal frame onto which a pre-cast concrete pad was laid to anchor the containers. Thus, the entire set-up could be relocated if necessary. The moveable container was used in areas where no curb and gutter existed or where alleys were soon to be constructed. The moveable container unit cost $35 to construct.

Second, nineteen containers, which pivot 180 degrees about a vertical axis, were installed and set permanently in concrete in areas where there was a vertical curb. The pivot feature was designed to allow the containers to be kept away from the street during non-collection days. (Illustration No. 6). On days collections were to be made, residents were asked to swing the container to the outside position. This movement would bring the roller, which was attached to the container, to the gutter line where the guide rail of the collection vehicle could make the pickup. The momentum of the pickup of the containe would return it to its original inside position.

ILLUSTRATION NO. 6

CURB SERVICE

Curbside collection was provided by temporary containers, roll out containers and permanently installed containers shown in this illustration. On collection day, the user turns the container out into the street. When it has been emptied, a mechanism in the stand turns it back to its location behind the curb.

18.a

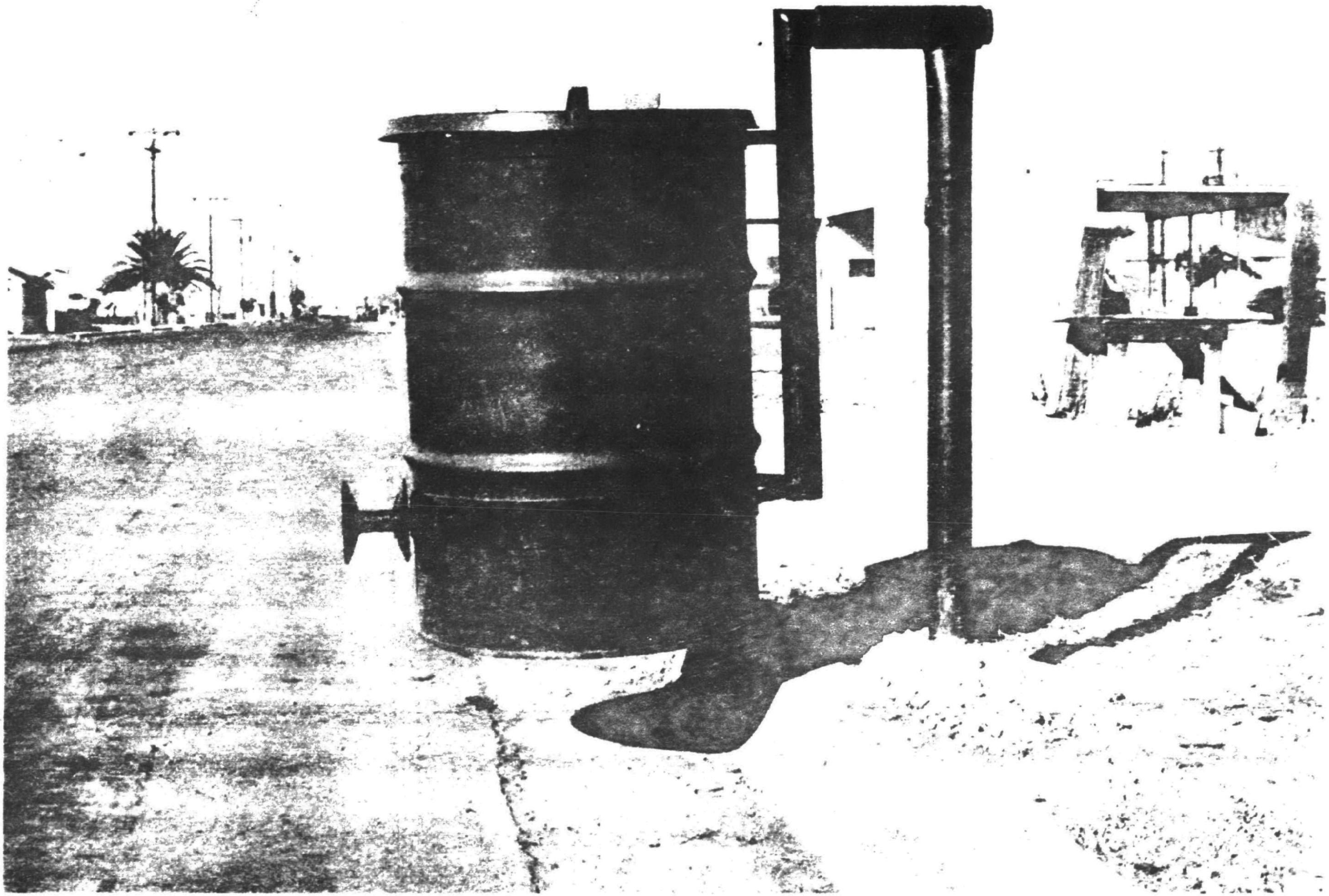
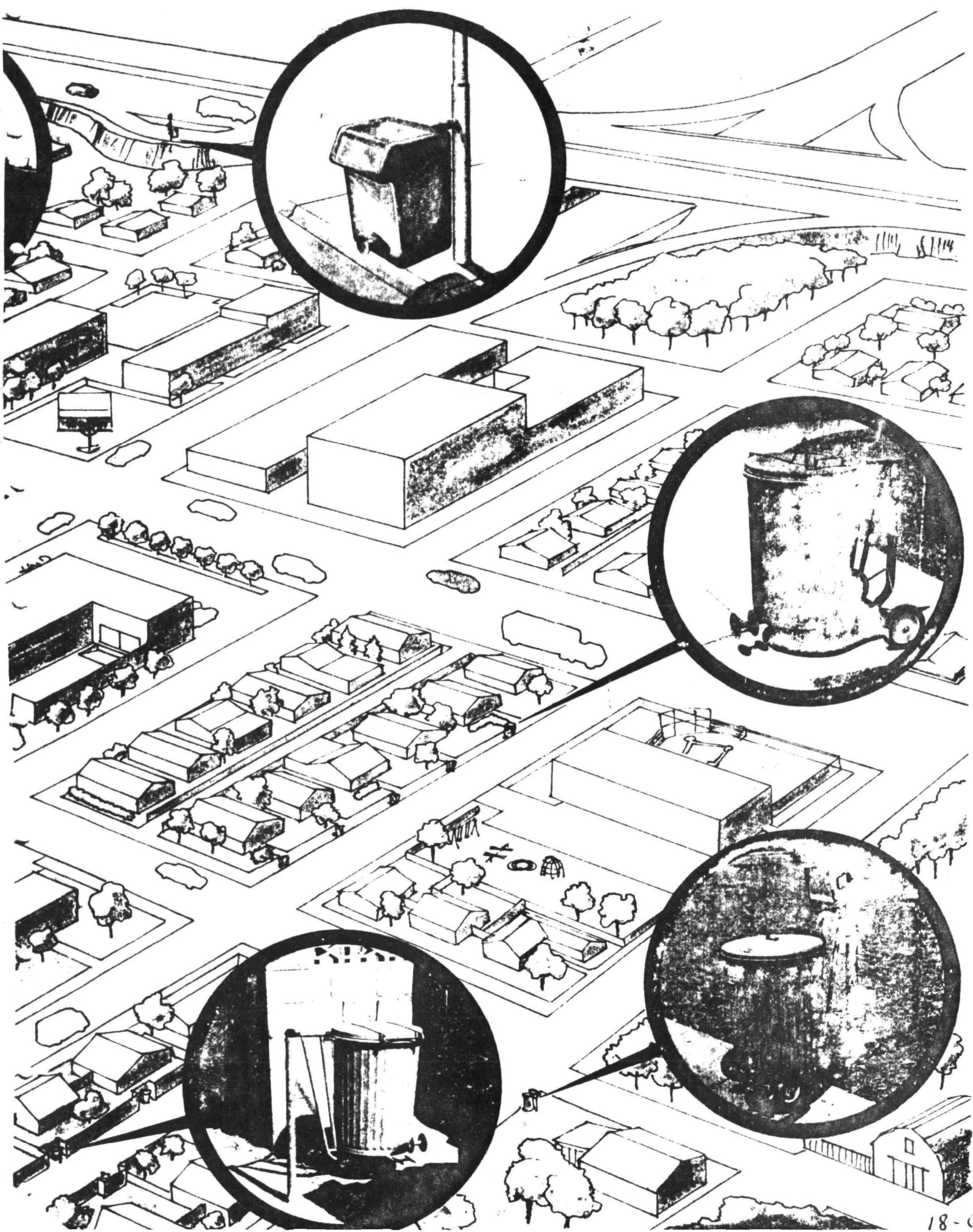


ILLUSTRATION NUMBER 6-A

OTHER TYPES OF CONTAINERS

The guide rail system could collect from a variety of containers at a variety of locations. This is and artists concept of some of those.



Third, a roll out type of container was given to one household. The post was permanently set in concrete, but the container wqs fitted with wheels and rolled out and attached to the post only on collection days. No lifting was necessary. Thus, the container could be stored away from the front of the home and wheeled about the yard for easy collection of grass clippings, hedge trimmings and general yard cleanings. The post, which was permanently installed, could serve other useful functions such as a street address marker, yard lights, mail boxes, and name plates.

Container Identification

After all containers had been installed, they were numbered in route sequence. These numbers enabled the driver to keep an accurate count of the homes served, the collection time required, and to correlate this data with the total weight collected on a daily data report form. In addition, these numbers were used to identify any problems with the container or any unacceptable practices by the people using the container .

Acceptance

As installations were completed, city crews distributed an instruction booklet and gave information on the new system to each residence. (Appendix B). These crews found residents eager to try the new system. Very little follow-up was required to insure compliance. The most difficult problem was getting the residents to place tree trimmings and other rubbish across the alley from the containers. At first, this material often blocked the path of the collection vehicle and the driver had to stop, disembark, and remove the obstructions. However, as residents became familiar with the collection vehicle and observed it working, they were more careful and did not leave obstructions in the path of the truck. After the first two weeks of service to an area, the driver found that he seldom had to leave the cab of the truck to remove rubbish or close an open gate.

Public acceptance of all types of curbside containers was surprisingly good. While a few people did object to the green color of the container, they did not seem to object to having the containers permanently in front of their homes. Initially, some difficulty was experienced with parked automobiles interfering with curbside collections. Parked cars became much less of a problem as people began to understand how the collection vehicle worked. Again, no special effo[illegible] were required to minimize the street parking. Residents voluntarily complie[illegible] once they understood the needs of the collection vehicle.

Load Densities

After all containers were installed and the new vehicle began to make its collections, it failed to achieve expected load densities. Density of 400 pounds per cubic yard was expected based upon our experience in Phase II. We were not able to attain these densities and began to experiment with meta[illegible] guides inside the packer shell to more evenly divide the refuse. None of [illegible] dividers were successful in correcting load deficiencies. The angle of packer ram was then changed into the packer shell. This change solved our density problems and density increased to 450 pounds per cubic yard.

Litter

The most remarkable benefit observed in Phase III was the clean-up of litter in the alleys. Some of this was undoubtedly due to the fact that animals such as dogs or cats were unable to gain entry into the containers and were thus not able to scatter the contents. In addition, there was strong evidence that residents had been raking up the small amount of papers and leaves regularly. This was a major improvement over the conventional system previously used as city crews frequently were required to clean up alleys. Since containerization, city crews have not needed to clean alleys.

Safety

Reports show the occupation of refuse collector to be a hazardous one. The Arizona Safety Council reports that the solid waste collection industry had the highest injury frequency of any industrial category in 1971.

Employees must spend their workday jumping off of collections trucks, picking up and dumping heavy containers with jagged edges, working close to moving machinery on a demanding, tiring job. The statistics are not surprising.

Safety is generally measured in terms of the frequency rate of disabling injuries. The frequency rate is determined by multiplying the number of disabling injuries times 1,000,000 and dividing the result by the total number of hours worked.

For the refuse collection industry as a whole, the frequency rate was 90.9 accidents per million man hours worked. For the operation of Tolleson's non stop truck, the frequency rate was zero throughout the entire period of the experiment. Thus, in an industry which has a higher frequency rate than police departments, logging, coal mining, and highway construction (Table 1), the mechanization program has demonstrated a perfect zero accident record.

The experiment demonstrated a man, riding in an air-conditioned cab away from packer blades and not required to lift and dump containers is a safer employee. He is less tired and therefore, more attentive to his work. He has less time off from work due to injury and is therefore a more productive employee. Mechanization not only saved production dollars, but also safety and industrial compensation dollars.

Displaced Workmen

If mechanization is to be welcomed by employees, displaced workmen must be given other employment. Two workmen were displaced in Tolleson by the introduction of the non-stop truck. One was put to work doing carpentry and cabinet making for the addition to City Hall. He also was used in the development of a new park by doing leveling, irrigation ditch and sprinkler system construction and dirt hauling. The other employee was placed in the city's water program as a crewman.

TABLE 1

FREQUENCY RATE OF DISABLING INDUSTRIES
1963-1970
SELECTED INDUSTRIES

INDUSTRY	FREQUENCY RATE PER MILLION MAN HOURS WORKED
Automobile Manufacturing	1.60
Chemical Acid Manufacturing	5.33
Structural Steel Fabrication	14.56
Structural Metal Work	15.84
Highway Construction	17.90
General Building Construction	19.26
Logging	19.96
Parks & Recreation Departments	26.89
Municipal Employee Administration	27.57
Fire Departments	32.96
Coal Mining	33.46
Police Departments	53.24
Solid Waste Collection	90.90

Source: Arizona Safety Council

These two placements in good jobs removed apprehension of employees for their job security. They know that non-stop collection has provided an opportunity for improved employment and job satisfaction.

Driver Training

Since the non-stop truck is simple to operate, driver training did not prove to be a problem. Once the motion of the container became familiar, driving the truck was easy. The inventor worked with the operator at first and rode with him on occasion to familiarize him with the principle of the non-stop truck and its operating characteristics. The first driver soon learned to adjust the collection rate to avoid littering or jamming the working mechanism. After he had gained experience and confidence, he trained a second back up operator who has relieved him when sickness, job assignment or vacation made it desirable.

Consumer Reaction

In order to adequately assess user attitude toward Tolleson's new, innovative method of solid waste collection, an attitude survey was conducted during Phase III in June, 1972.

The consultant prepared a list of statements for the survey which were designed to test various areas of citizen reaction to mechanization and non-stop collection. The statements were reviewed and prepared in the form of an interview sheet. (Appendix C) The questionnaire was translated into Spanish by our personnel so that Tolleson's Spanish speaking population could understand and comment meaningfully on the statements presented.

The interview sample was selected by including in the survey every fifth house on the collection route.

Fifteen statements were presented by the city interviewer and the householder was asked to respond to the statement as follows: Strongly agree, agree, disagree, strongly disagree. The interviewer would them mark the response on the interview sheet for the respondent. This system reduced the chance for improper or hasty marking by a resident.

The responses were most favorable to the non-stop method of collection. The first statement was "The new method is an improvement over the old one," and 98.6% indicated a favorable response. Of the 98.6%, 80.0% said that they strongly agreed with this statement and 18.6% said they agreed. In two questions, the users were asked if they wanted to return to the old system and their reaction was negative by a large margin.

Statements were included which related directly to performance of the non-stop method of collection. Of the respondents, 83.4% felt that their refuse was being collected often enough, 86.9% that their container provided adequate capacity, and 97.9% that the city employee collecting did a good job.

To the statement that the system reduced noise of collection, 37.9% responded that they strongly agreed and 40.0% said thay agreed. The adjustments made early in the experiment to reduce noise were evidently successful in solving the problem to the point that users felt it was quieter than the old method. In terms of sanitation, 98.6% were favorable to the statement that the containers keep out dogs and cats. This response, we felt, was especia' important to our analysis as experience has shown that householder-provided containers are susceptible to animals. Litter and garbage were, all too often, spread around the city's streets and alleys. Likewise, 93.8% felt the area around the new containers was easier to keep clean, as animals were not continually spreading litter around.

The response, however, did not entirely favor mechanization. For example, 35.9% felt that it costs less to collect refuse by hand than by machine. The analysis of the economics of non-stop collection in this report show it to be considerably less expensive than hand collection. To the statement that it is faster to collect refuse by hand than by machine, 13.8% strongly agreed and 14.5% agrees. Again, the results of the study show mechanization much faster than hand collection. These responses, although not majority responses, represent a substantial portion of the users and point out the need for continued education of the public in these areas.

Each resident interviewed was given the opportunity to mention what he disliked about the non-stop system. Over half stated that they had no major dislikes. The most often expressed dislike, at 12.8% of the response was that the container was too small and 7.8% disliked having to place their trash across the alley.

They were also given the chance to respond to the statement "What do you like most?" Of the responses to this question, one third said that they had no special like, 14.7% said they like the containers because they kept the animals out, 11.3% felt the system was convenient and 8.7% liked the reduction in flies around the container.

The Phase III attituude survey demonstrated strong citizen support for mechanization and the use of the non-stop collection vehicle. It pointed out, however, the need for further education of the public on economics and productivity. The City Council and staff feel that this survey supports their experimental efforts in providing better and less expensive solid waste collection service.

Public Relations

The project had good coverage from the media. In August, 1971, KTAR, an affiliate of NBC, filmed a short two minute video tape which adequately explained the system. This tape was subsequently picked up by the wire services and carried in many cities on the NBC Brinkley Report. In November 1971, our local ABC affiliate, KTVK-TV, carried a video tape of the operation. Local newspapers, having statewide circulation, the Arizona Republic and Phoenix Gazette, have carried several accounts of the progress of the project. In addition, a local weekly, the Westsider, has carried several articles on the demonstration. U.S. News and World Report carried pictures and a very brief description in its April 10, 1972 edition. An article has been prepared and pictures sent to American Cities and Western Cities Magazines for printing in a current issue.

Response from the public following television coverage and articles in magazines and newspapers has been wide spread. Inquiries have come from as far away as Agana, Guam. The vehicle and system has been shown to representatives of Huntington, West Virginia, the Arizona cities of Phoenix, Avondale, Buckeye, Scottsdale, Chandler, Casa Grande, Huachuca City, Peoria, South Tucson, and Kearny. Several hundred requests for information have been received from cities all over the nation.

Experience with Manufacturer

Demonstration of the non-stop collection system required some unusual relationships with the inventor-manufacturer. Since the system had never been tried before in another city we could only use very general specifications. The inventor was to retain any patent rights under the terms of the grant and agreed in return to provide all design, development, modification and other work needed to produce a working system. The manufacturer was most willing to make corrections and to replace and repair parts or components that failed during trials and later use. He was always available on short notice, operated the equipment at his expense for several months to collect the Phase II alley data whicle improving the mechanization and making improvements in the stands and the truck.

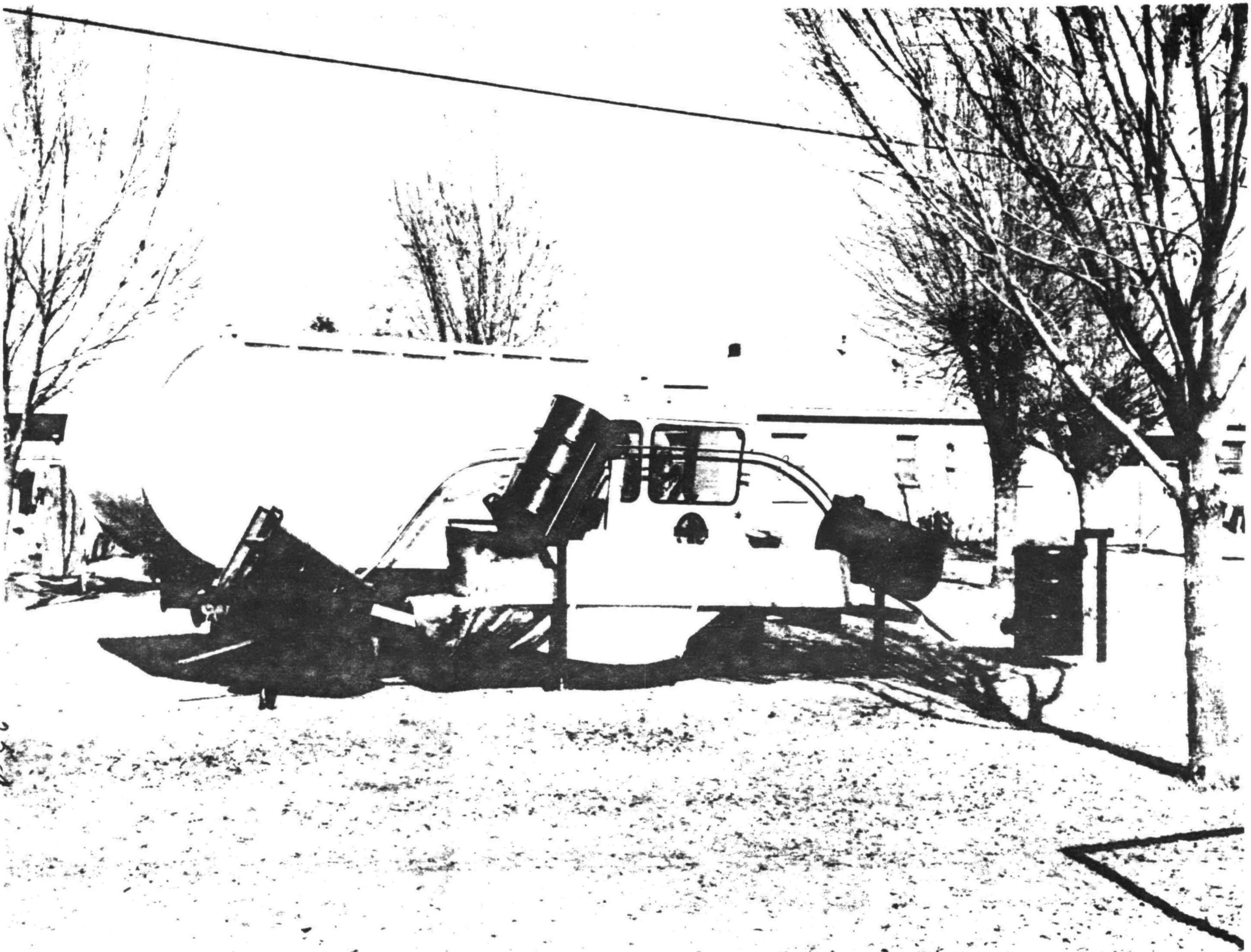
The stands and the truck have been comparatively trouble free. The quality of the prototype equipment was excellent, especially considering that it was manufactured as prototype equipment on a short run basis.

Status of Patents

Patent applications on several non-stop collection systems had been filed by the inventor before work on the demonstration was started. Both of the inverting systems - one using a soft tire bumper and the other using the guide rail - were ideas covered by these applications. The U. S. Patent office has reviewed the applications and accepted many of the claims. The inventor should soon have established patent rights on the system.

ILLUSTRATION NO. 7

The non-stop truck collecting in Phase III used the guide rail system.



Economics and Productivity

The most important objective of Phase III was to evaluate the economics of non-stop refuse collection and the productivity of the non-stop truck. To do this, detailed records were required and the refuse collection crews were relied on heavily to collect the information. They did an excellent job throughout the experiment and the results of their effort form the basis of this discussion.

The evaluation of the economics and productivity of a collection vehicle involves a number of factors including crew size, load capacity, rate of collection, investment costs, operating and maintenance expense, haul time, work hours, frequency of service and level of service. These elements make up the unit cost of refuse collection per home per month and make it possible to compare performance of one method of collection with another.

As a basis for comparison, the appropriate cost data was collected and the monthly cost of operation was determined. This expense is the total of the cost of labor, administration and overhead, operating and maintenance, and amortization of equipment purchase. The data for the rear end loader applies only to residential collection and was collected prior to Phase III. Below is an item by item discussion of these elements of the operating costs.

The most expensive item in the refuse collection unit cost analysis was labor. For the conventional truck, the rear end loader, the crew consisted of a driver and two workmen. During the haul to the disposal site, these two workmen rode in the truck and were drawing full wages even though they were unproductive in terms of refuse collection. For the non-stop truck, only one employee was required to both operate the vehicle and provide for the collection of the refuse. Thus, only one employee, the vehicle operator, made the trip to the disposal site.

The difference in crew size and the resulting reduction in unproductive man hours during hauling had a major impact on collection labor costs. Whereas it required three men an average of 297 man hours per month to serve the city's residences prior to the demonstration project, the non-stop method required only 88 man hours per month. The average cost per month for the 297 man hours for the rear end loader was $855 and for the non-stop truck $279. The City of Tolleson was able to save $576 per month in labor costs due to the conversion to the non-stop collection system.

Since it was extremely difficult to identify administration and overhead expense in an organization that provides a variety of public services, a rate of 30% was used to account for these costs. By using this percentage, we have in essence placed the highest expense burden on the collection system using the most manpower. We feel this percentage application was justified on the basis that it requires more administrative support and overhead costs to maintain a three man crew than a one man crew.

On this basis, administration and overhead expense for the rear end loader was $256.50 per month and for the non-stop truck, $83.70 per month.

Operating and maintenance costs for this analysis included the cost of gasoline, oil, lubrication and routine servicing and repair work. During this demonstration project, there were surprisingly few repairs to the mechanized vehicle. The major modification made in the vehicle was the Phase II switch from the bumper to the guide rail method of collection. This change was not due to mechanical problems but, rather, was due to the finding that the bumper method required smooth alleys, evenly spaced containers and constant collection speeds and was, therefore, impractical on a large scale.

The major repair problems concerned some aspects of the sweep arm. The first problem with the sweep arm occurred when the locking screws became loose causing the shaft to slip in the bearings. This action damaged the O ring seal in the slip ring due to misalignment with parts in the shaft. The inventor bolted the retaining cap to the shaft to prevent slippage, the seals were replaced and the valves and lines were cleaned.

On another occasion, the slip ring was damaged by being locked to the shaft by coat hangers wrapped around the sweep arm support frame. The problem was corrected by replacing the slip ring and hydraulic lines and adding a shield between the slip ring and frame.

The inventor made a number of miscellaneous repairs including the replacement of broken oil line fittings, adjusting pressure control switches and cam operated switches, replacing fuses, adding supports to the guide rail, straightening the side of the chute, straightening bent guide rail, replacing wooden sweep arm, and adding a deflector for better compaction.

These repairs and modifications required a total of 72 man hours of the inventor's time during January 1 - June 30, 1972. Some of them will be eliminated by improved design in future models of the non-stop truck. A cost of $720 for labor, $100 for parts and $25 for miscellaneous expenditures has been assigned for the inventor's charges

During this same period, City of Tolleson personnel made $212.32 in repairs including labor and parts which brought the total cost for repairs for six months to $1,057.32 or $176.22 per month. The rear end loader averaged $95.63 per month for repair costs for the last six months of 1971.

Costs for gas and oil during Phase III for the non-stop truck were $39.41 per month as shown in Table 2 The rear end loader averaged $60.39 for fuel and oil in the six month period prior to Phase III for residential collection.

Adding the repair costs to the fuel costs, we can determine the total operating and maintenance cost for the non-stop truck and rear end loader. Monthly repair costs averaged $176.22, oil costs $6.51 and gasoline costs $32.90. The average monthly operating and maintenance cost for the non-stop truck was $215.63 while, in the six months prior to Phase III, the rear end loader averaged $156.07 for operating and maintenance expense.

TABLE 2
FUEL COSTS
NON-STOP COLLECTION TRUCK
TOLLESON, ARIZONA
JANUARY 1, 1972 - JUNE 30, 1972

	OIL		GASOLINE	
MONTH (1972)	QUARTS	COST	GALLONS	COST
January	6	$ 2.58	146.7	$ 33.62
February	5	2.15	134.0	30.71
March	2	.86	146.4	33.55
April	7	3.01	139.0	31.86
May	8	3.44	140.0	32.09
June	7	3.01	155.1	35.55
Total	35	$15.05	861.2	$197.38
Oil Filters		4.00		

Total Oil and Gasoline Per Month - $39.41

These operating and maintenance expenses are extremely low when compared to those experienced by other communities. Scottsdale, Arizona, experienced operating and maintenance expenses approaching $1,000 per month for a rear end loader and $1,500 per month for their recently developed "Barrel Snatcher." The substantially lower cost experienced by Tolleson may be due to the fact that the non-stop truck was in operation only 88 hours per month and the rear end loader 99 hours per month, whereas Scottsdale's trucks averaged in excess of 172 hours per month.

For amortization of the purchase price of the vehicle we have selected the straight line method of depreciation and have assumed that the trucks will have no resale value. It is felt that the non-stop truck and the rear end loader have a productive life of seven years, but at the end of that period, will be of little or no value.

The non-stop truck was not an expensive truck by refuse collection standards. Due to the uncomplicated nature of its construction, the truck was marketed as a prototype for $13,200 by the inventor. By comparison, the rear end loader was purchased by the City of Tolleson for $24,000. Applying the straight line, seven year depreciation with no resale value to the two trucks, the monthly depreciation for the non-stop truck in Phase III was $157.14 and for the rear end loader, $285.71.

<u>Unit Costs</u>

By taking these average monthly costs we can determine the cost per home per month for collection service. For the non-stop truck, however, we must add the cost of the container amortized over its expected lifetime.

The 55 gallon installations have a ten year estimated life. This period may seem long but is based upon the fact that the installations are all steel and painted with a rust resistant paint. A recent analysis of the containers after they had been in service for over a year revealed that they have experienced negligible structural wear, even on the moving parts, and the paint has withstood weather and usage.

Assuming they will either require repainting after five years in service or will need some type of repair during their ten year life, a cost of $3.00 per container has been estimated for spray painting or, if required, minor repair work. Adding to this the $30.07 for purchase and installation of each container, the total cost per container over the ten year period would be $33.07. For ten years, the cost for the container dwelling unit per month would be $.28.

Table No. 3 presents the summary of collection costs.

TABLE 3

VEHICLE COLLECTION COST
PER MONTH

COST ITEM	REAR END LOADER	NON-STOP TRUCK
Labor	$ 855.00	$279.00
Administration & Overhead	256.50	83.70
Operating & Maintenance	156.07	215.63
Depreciation	285.71	157.42
Total Collection Costs	$1,553.28	$735.75

Dividing this total collection cost by the number of residences served, the cost per home per month can now be determined. With 363 residences served by both the non-stop truck and the rear end loader, the cost per home per month for the rear end loader in the six months prior to Phase III was $1.80, excluding the homeowner's cost for a container or plastic bags, and for the non-stop truck in Phase III. $.86 plus $.28 for container amortization for a total of $1.14. Using one man in an easy-to-operate mechanized vehicle, the City of Tolleson has been saving $.66 per home per month in collection costs while providing an attractive and neat container that improves sanitary conditions in the alley.

This comparative data was developed for the non-stop and conventional systems as they have actually operated in Tolleson. Before using the data to develop comparison in other applications, several areas must be considered.

Vehicle Capacity

Capacity of the haul body is an important factor in collection vehicle evaluation. The non-stop truck has a small capacity compared to conventional collection trucks. The non-stop truck's capacity of 10 cubic yards compared to the conventional rear end loader with a capacity of 20 cubic yards is disadvantageous when haul distances are significant. Larger capacity trucks spend more time collecting and less time hauling than the non-stop truck, although the fact that they cost more to purchase must be weighed in the anlaysis.

For purposes of the economic analysis, capacity may be expressed in terms of residences served per loaded trip to the landfill. In this experiment, the non-stop collecting three times per week truck averaged 263 homes per loaded trip to the landfill. The rear end loader contained, on the average, refuse from 450 homes per loaded trip to the landfill for twice per week collection.

Rate of Collection

The rate of collection expressed in terms of homes served per hour of collection excluding haul time is valuable in determining refuse collection productivity.

The non-stop truck in Phase III averaged 174 homes per hour of collection. The rear end loader averaged 85 homes per hour. The conventional collection crew thus collected at a rate of 28 homes per manhour on a twice per week basis. Each manhour provided twice a week service to 14 homes, compared to a rate of almost 60 homes three times per week service with the non-stop truck. While collecting, the non-stop system uses labor 4.3 times as productively as the old conventional system.

Haul Time and Distance

The round trip distance to the Tolleson landfill averaged 9.0 miles in Phase III. The non-stop truck proved to be faster in making this round trip, probably because of its smaller size. We found that the new truck could make the trip in an average of 34.5 minutes compared to 41.1 minutes for the rear end loader.

The non-stop truck can also empty faster at the landfill. The rear end loader ejects by means of a hydraulically powered plate. The non-stop truck empties like a dump truck which is much faster.

As haul times increase, it is apparent that the advantages of the one man system also increase. The labor cost, which is the most expensive item in conventional refuse collection is increased three times during the period of the haul for the three man crew.

Using a formula developed by the City of Scottsdale, it is possible to express these factors in terms that allow comparisons with other systems and enable certain cost areas such as haul cost to be isolated. The basis of Scottsdale's formula is the cost per dwelling unit per month.

The formula to determine the cost per dwelling unit per month is as follows:

$$\frac{(\text{No. of Pickups/Month})(\text{Cost of Operation/Month})[(\text{Capacity}) + (\text{Rate})(\text{Haul time})]}{(\text{Work hours/month})\quad(\text{capacity})\ (\text{rate})}$$

$$+ \text{ container cost} = \text{cost per dwelling unit}$$

In more simplified form, this formula can be expressed as

$$\text{Cost} = \frac{(\text{No. of Pickups})\ (\text{Cost of Operation})}{(\text{Work hours})\ (\text{Rate})}$$

$$+ \frac{(\text{No. of Pickups})\ (\text{Cost of Operation})\ (\text{Haul Time})}{(\text{Work hours})\quad(\text{Capacity})}$$

$$+ \text{ Container cost}$$

The total cost is the sum of collection cost, haul cost, and container cost.

UNIT COST = Collection cost + Haul cost + Container cost

The cost elements of the formula are defined below:

Number of Pick ups Per Month: The number of pick ups per month is the number of times service is provided to the generator. In Tolleson, refuse pick up is provided on a three timess per week basis with the non-stop truck and twice per week basis with the rear end loader.

Cost of Operation: The cost of operation is the total of labor, administration and overhead, operating and maintenance and amortization expenses for each vehicle expressed as a monthly figure.

Capacity: The capacity of a vehicle is the number of homes the vehicle can serve per loaded trip to the landfill. The capacity varies with the amount of generation per household.

Rate of Collection: The rate of collection is the number of homes the vehicle can serve in one hour of collection excluding haul time.

Haul Time: The haul time is the time required for the vehicle to make a round trip to the landfill. This time depends on the speed of the vehicle and the distance of its route from the landfill.

Work Hours Per Month: The work hours per month is the number the vehicle is in operation per month.

Applying this formula to the rear end loader, the result is as follows:

$$\text{Collection cost} = \frac{(8.6)\ (1553)}{(99)\ (85)} = \$1.59$$

$$\text{Haul cost} = \frac{(8.6\ (1553)\ (.69)}{(99)\ (450)} = \$.21$$

Container cost = No container cost has been assigned to the rear end loader system as the generator provides the container. The attempt here is to identify only city cost of collection.

The total cost of refuse collection per dwelling unit per month is $1.59 + $.21 or $1.80.

For the non-stop truck, the results are as follows:

$$\text{Collection cost} = \frac{(13)\ (736)}{(88)\ (174)} = \$.62$$

$$\text{Haul cost} = \frac{(13)\ (736)\ (.58)}{(88)\ (263)} = \$.24$$

Container cost = $.28

The total cost of the non-stop system is $.62 + $.24 + $.28 or $1.14 per dwelling unit per month.

These results demonstrate that the non-stop method of collection is saving the City of Tolleson $.66 per dwelling unit per month or $6,874.55 per year. This savings is accomplished by a system that provides a container for each residence, requires only one employee to operate and leads to cleaner, neater alleys. Obviously, the greater the number of the dwelling units served, the greater the amount of savings that will accrue to the community.

The effect of increased haul time on the economics of collection can be shown further by calculating haul cost for various lengths of haul time:

HAUL COST
NON-STOP TRUCK

Haul Time In Hours	Service Cost	Haul Cost	Total Cost
0.5	$.62	$.21	$ .83
1.0	.62	.41	1.03
2.0	.62	.82	1.44
3.0	.62	1.23	1.85
4.0	.62	1.64	2.26

HAUL COST
REAR END LOADER

Haul Time In Hours	Service Cost	Haul Cost	Total Cost
0.5	$1.59	.15	$1.74
1.0	1.59	.30	1.89
2.0	1.59	.60	2.19
3.0	1.59	.90	2.49
4.0	1.59	1.20	2.79

Again, increasing the capacity of the non-stop truck would have a dramatic impact on haul cost. If the non-stop truck could contain 450 homes per load, at four hours of haul time the haul cost would be $.97 compared to $1.20 for the rear end loader.

It is interesting to note the comparative haul cost. The non-stop truck demonstrated a haul cost of $.24 per dwelling unit per month, $.03 per dwelling unit per month more than the rear end loader. As noted previously, the rear end loader has three workers and the non-stop truck only one. This labor cost during hauling gives the non-stop truck a considerable advantage but in this case, the non-stop truck's advantage was offset by its low capacity in terms of homes served per loaded trip to the landfill (450 homes per load for the rear end loader vs. 263 for the non-stop truck).

If the non-stop truck had a capacity of 450 homes per load the haul cost would be as follows:

$$\text{Haul cost} = \frac{(13)\ (736)\ (.58)}{(88)\ (450)} = \$.14$$

The total cost per dwelling unit per month would be reduced to $1.00, $.80 less than the rear end loader system.

One would expect future models of the non-stop truck to be designed with a greater capacity than the vehicle used in this experiment. In fact, the inventor has under construction, at this time, a 16 cubic yard non-stop truck that could be expected to have a capacity of approximately 420 homes per load.

Conclusion

Phase III concerned the city wide implementation of the non-stop system. A total of 868 containers were installed by city forces. The new method resulted in a reduction of litter in the alleys primarily because dogs and cats could not gain entry to the containers, dump them out, and spread their contents throughout the alley.

The non-stop system proved adaptable to curbside collection through the use of three different curb container installations including one which allows the homeowner to move his container by means of wheels.

The non-stop system received wide spread publicity during Phase III including coverage on the NBC Brinkley Report and an article in U. S. News And World Report. Several hundred letters of inquiry have been received and answered by the Tolleson staff.

During the entire experiment, the non-stop truck had a perfect safety record. This accident free performance was achieved in an industry that has a safety record worse than police work and logging.

An attitude survey conducted in Phase III demonstrated strong citizen support for mechanization. Nearly 99 percent of those surveyed felt non-stop collection is an improvement over the rear end loader method of collection.

The analysis of the economics and productivity of non-stop collection demonstrates that it is an attractive alternative to the rear end loader. In terms of productivity, one man was serving the entire community with service three times per week in 88 hours per month. The rear end loader, with a crew of three, needed 99 hours per month or 297 man hours to provide twice a week service.

The cost per dwelling unit per month totalled $1.80 for the rear end loader system and only $1.14 per dwelling unit per month for the non-stop truck. The City of Tolleson is saving $.66 per dwelling unit per month through use of non-stop collection. When multiplied by the number of dwelling units, this savings is substantial even for a small community such as Tolleson.

APPENDIX A

LETTER TO PHASE I PARTICIPANTS

City of TOLLESON

CITY MANAGER
Bill R. DaVee

CITY CLERK
Esther Angulo

SUPT. OF
WASTE WATER
TREATMENT
Jack L. Muir

CHIEF OF POLICE
Wayne Watson

9555 WEST VAN BUREN TOLLESON TOLLESON, ARIZONA 85353

MAYOR
Charles Morriott

VICE-MAYOR
Vince R. Canalez

COUNCILMEN
Charles H. Beebe
Lucy T. Bohne
P J. Green
Elden Jensen
Frank O. Rivera

Feb. 19, 1971

Dear Citizen of Tolleson:

Your neighborhood has been selected to receive Tolleson's unique containerized collection service. The City has developed the containerized system over the past year to assure you of better service at no additional cost.

Each home in your neighborhood is being provided with a 55 gallon container that is attractive, durable and easy to keep clean. The ample capacity means that only rarely will you have excess refuse. If there is an excess, you should store it and place it in the container for the following collection day. Please do not pack the containers tightly. Place excess trash to the opposite side of the alley from your container. Do not place any refuse on top of the container lid.

We hope that you will find your new service to be better than any you have received in the past. Now we need your help. We encourage you to contact us if you have any suggestions. Please call Bill Da Vee at 936-1161. Your home will be served on Monday, Wednesday, and Friday.

Sincerely,

Bill R. DaVee

Bill Da Vee
City Manager

BRD/mc

APPENDIX B

PHASE III INSTRUCTIONAL BOOKLET

City of TOLLESON

City of TOLLESON

9555 WEST VAN BUREN TOLLESON TOLLESON ARIZONA 85353

OFFICE OF THE CITY MANAGER
Phone 936-1871

Dear Tolleson Resident.

The City of Tolleson has been granted funds by the Federal Government to demonstrate a new system of refuse collection. It can mean money savings to you directly and indirectly.

By using special containers furnished by the City, you will no longer have to purchase garbage cans for your everyday household refuse. The containers furnished by the project will not cause increases in present charges or additional fees.

With this system, your city can save tax dollars *your tax dollars* – by using the unique refuse collection truck that automatically dumps the large refuse containers being used and the job is done faster and cleaner than past methods.

We are most happy to be able to include all Tolleson residents in the first attempt ever made to completely automate refuse collection. Under the Federal grant project, the City will be an example to the rest of the nation.

The City of Tolleson officials sincerely appreciate your cooperation and take this opportunity to illustrate on the following pages ways to insure the most in user satisfaction

Bill R Da Vee
City Manager

Residente de Tolleson.

El Govierno Federal le ha proporcionado a la Ciudad de Tolleson fondos para demonstrar un systema nuevo de levantar basura Este systema le ahorrara dinero a usted directamente e indirectamente.

Haciendo uso de estos botes de basura que la ciudad le proporciona ya no sera necesario que usted compre su propio bote. Estos botes que proporciona la ciudad no le costaran a usted ningun costo adicional

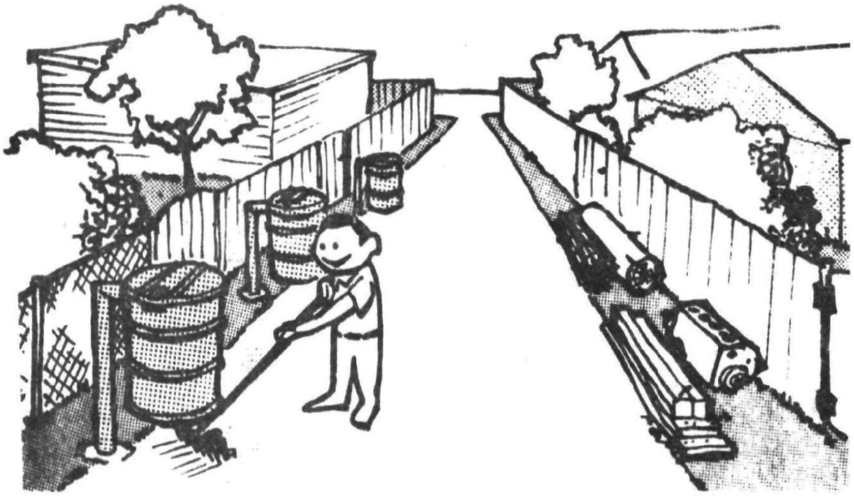
Con este systema su Ciudad podra ahorrar gastos de impuestos *que es su dinero* Usando este systema este proyecto sera mas rapido y mas limpio

Tenemos el gusto de anunciarles a todos ustedes los residentes de Tolleson que este sera la primera vez que este proyecto sera completamente automatico. Bajo este donativo Federal sera un ejemplo la Ciudad de Tolleson para el resto de la nacion

Los oficiales de la Ciudad de Tolleson toman esta oportunidad para expresarles su sincero agradecimiento y tamien para demonstrarles en las siguientes pajinas los medios para asegurarles a ustedes satisfaccion en este servicio

Bill R Da Vee
Gerente de la Ciudad

INTRODUCES
A NEW REFUSE COLLECTION SYSTEM

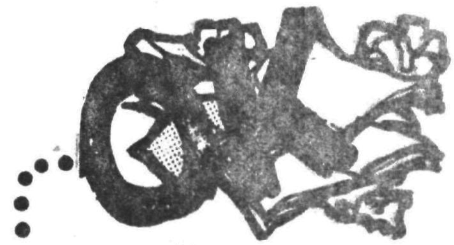


BUILT IN CONTAINERS
YOU DON'T HAVE TO BUY!
NO TENDRA QUE COMPRAR
BOTES DE BASURA.

- Refuse cans installed and paid for by your city.
- Estos botes seran instalados y pagados por su Ciudad.
- Easy to clean around and under, for a cleaner, healthier city.
- Para una Ciudad mas limpia y sana, estos botes son faciles para limpiarse tanto abajo come alrededor del bote.
- Faster, cheaper pickup.
- Se levantara la basura mas rapido y mas barato.

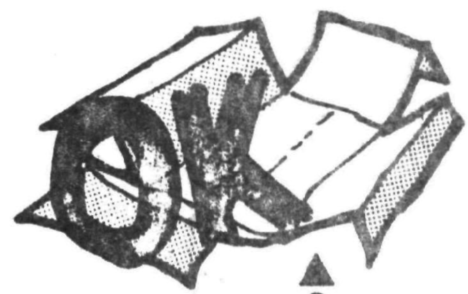
Loose grass cuttings and hedge trimmings should be dumped into cans loosely.

Sacate y ramas chicas de su patio se pueden tirar en los botes sueltamente.



Don't bundle newspaper and magazines.

Libros y papeles tambien se tiran sueltos – no los hagan bola ni los amarren.

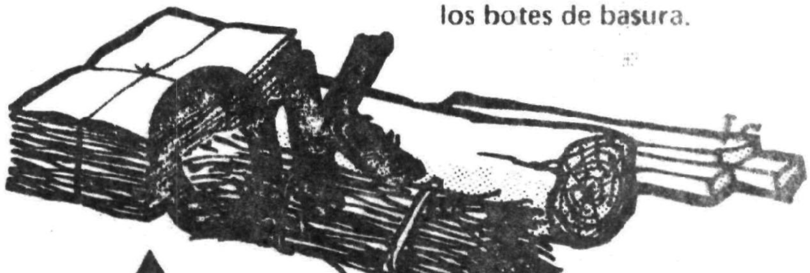


Boxes should be torn apart before putting them in cans.

Cajas de carton deben ser despedazadas antes de tirarse en los botes de basura.

All kinds of loose refuse and garbage.

Tire toda clase de desperdicios y basura suelta en los botes.



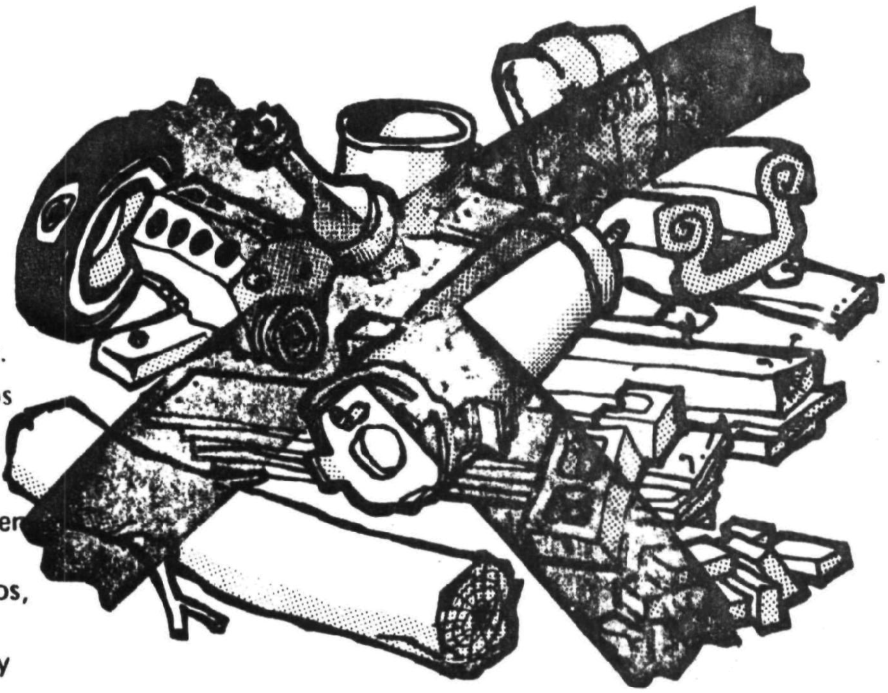
Tree trunks and branches, building materials, bundled newspapers and magazines, car parts, etc., should be stacked neatly across the alley, opposite the cans.

Troncos de arboles y ramas, materiales de construccion, periodicos, revistas, partes de automovil y otras cosas grandes deben ponerse al lado opuesto de los botes.

ESTA ES UN SYSTEMA NUEVO PARA LEVANTAR LA BASURA

DON'T USE THE CONTAINERS FOR:

NO USE LOS BOTES PARA LO SIGUIENTE:



- ● Old auto parts, such as motor blocks, etc.
- ○ Partes de automovil (como motores viejos
- ● Tree trunks and branches
- ○ Troncos de arboles o ramas
- ● Construction materials (old lumber, cement blocks, etc.)
- ○ Materiales de construccion, como ladrillos, o bloques de cemento y madera vieja
- ● Hot water heaters, refrigerators, or heavy appliances
- ○ Tanques de agua caliente, refrigeradores, o estufas viejas

STACK NEATLY ACROSS THE ALLEY FOR SEPARATE PICKUP

TODO ESTO SE PONE AL LADO OPUESTO DE LOS BOTES DE BASURA PARA QUE LO RECOJA OTRA TROCA.

YOU CAN HELP MAKE TOLLESON THE CLEANEST CITY IN THE COUNTRY

USTED PUEDE AYUDAR A LA CIUDAD DE TOLLESON SER LA MAS LIMPIA EN TODO EL PAIS

Don't stamp down trash or jam boxes into cans.

No apriete o apachurra la basura o cajas de carto en los botes, ni tampoco brinque en los botes para apachurrar la basura.

This system saves time . . . and faster picku means tax dollar savings.

Este systema ahorra dinero, y ahorra mas tiempo o es decir, ahorra de sus impuestos, y a la vez es mas rapido.

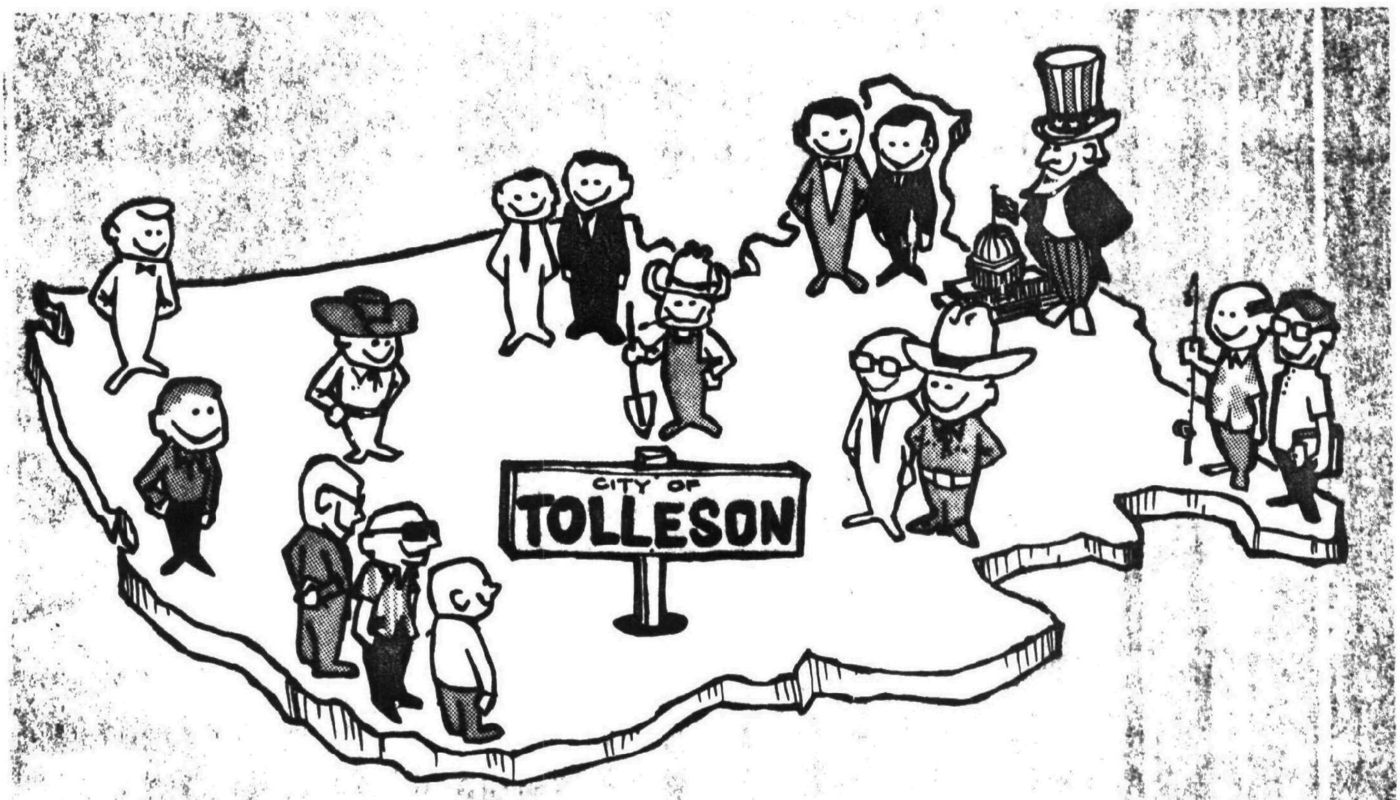
NOTICE: For pickup of dead animals, explosives, acids and dangerous chemicals, call 936-1871 for special truck.

NOTICIA: Para que levanten animales muertos, explosivos, acidos o quimicos peligrosos, llamen al telefono 936-1871 – Se habla Espanol.

FOR MORE INFORMATION, CALL 936-1871 **SE HABLA ESPANOL**

THE ENTIRE COUNTRY HAS ITS EYE ON...
TODA LA NACION ESTA VIENDO A ...

TOLLESON



APPENDIX C

PHASE III QUESTIONNAIRE

CITY OF TOLLESON MECHANIZED REFUSE COLLECTION QUESTIONAIRE

Interviewer____________________

Address____________________
Call dates and times__________
____
____

Generator type:
House______
Apartment or townhouse
Commercial______

Interview No.______________
Date______________
Time______________
Number of people in the household__________
Sex of respondent M__ F__
Approx. age:____________
Less than 10
10-20________
20-35________
35-50________
50-65________

A. "Hello, I'm____________________representing the City of Tolleson.

B. As you know, the City has begun using a new refuse collection which uses containers on stands provided for each household.

C. We want to find our your opinions about present refuse collection service.

What do you dislike most about the new mechanized system?

Anything else?

What do you like most?

Anything else?

D. I'm going to read a few statements, and I would like to know if you strongly agree with them, agree with them, disagree, or strongly disagree with them. (Give sample questionaire to interviewee in appropriate language.)

Circle Correct Answer	Strongly agree	Agree	Dis-agree	Strongly Disagree
1. The new method is an improvement over the old one.	1	2	3	4
2. Refuse is being collected satisfactorily by the new system.'	1	2	3	4
3. Refuse is being collected often enough.	1	2	3	4

4.	City employees who collect refuse are doing a good job.	1	2	3	4
5.	It costs less to collect refuse by hand than by machine.	1	2	3	4
6.	It is faster to collect refuse by hand than by machine.	1	2	3	4
7.	I would rather go back to the former collection method.	1	2	3	4
8.	The area around the new refuse containers is easier to keep clean with the new system.	1	2	3	4
9.	The new system reduces noise.	1	2	3	4
10.	The new system adds prestige or status to the city and neighborhood.	1	2	3	4
11.	The city should go back to the old method.	1	2	3	4
12.	My container is large enough.	1	2	3	4
13.	New containers keep out dogs and cats.	1	2	3	4

Thank you for your opinions and cooperation.

QUESTIONARIO SOBRE EL MECANISMO DE BASURA QUE SE USA EN LA CIUDAD DE TOLLESON

Intrevistor______________________ Numero de intrevista______________

Domicilio______________________ Fecha______________________

Fetchas y veses______________________ Hora______________________

______________________ Numero de personas en casa________

______________________ Sexo de demandado______M______F____

Tipo de Generador:
Casa__________
Apartamento o vivienda________
Commercial________

Edad approx.________
Menos de 10
10-20______
20-35______
35-50______
50-65______

A. Buenos dias (o tardes), yo soy ______________________ y represento a la Ciudad de Tolleson.

B. Como Ud. sabe, la Ciudad ha empezado a usar un systema nuevo para levantar la basura. Por el cual, la Ciudad le proporciona el bote de basura para cada casa.

C. Queremos saber su opinion sobre este servicio.

Que es lo que <u>mas</u> le disgusta de este systema?

Que otra cosa?

Que es lo que mas le gusta?

alguna otra cosa?

D. Voy a leerle unas cuantas frases y quiero saber si Ud. esta de acuerdo con ellas o no esta.

Marque la respuesta indicada	(1) Rigorosamente de acuerdo	(2) De Acuerdo	(3) Opuesto	(4) Rigorosamente Opuesto
1. El nuevo metodo es mejor que el systema viejo.	1	2	3	4
2. Este systema de levantar la basura es satisfactorio.	1	2	3	4
3. Levantan la basura segido.	1	2	3	4

4.	Los empleados de la ciudad que levantan la basura trabajan bien.	1	2	3	4
5.	Cuesta menos levantar basura a mano que con maquina.	1	2	3	4
6.	Es mas rapido levantar la basura a mano que con maquina.	1	2	3	4
7.	Yo prefiero el systema viejo para levantar la basura.	1	2	3	4
8.	Con el systema nuevo es mas facil tener limpio el aria en donde estan los botes.	1	2	3	4
9.	El systema nuevo reduce el ruido.	1	2	3	4
10.	El systema nuevo le da prestigio o clase a la ciudad y la vecindad.	1	2	3	4
11.	La ciudad deberia volver al systema viejo.	1	2	3	4
12.	Mi bote de basura esta bastante grande.	1	2	3	4
13.	Con los botes nuevos los perros y gatos no se pueden meter.	1	2	3	4

Gracias por sus opiniones y por su cooperacion.