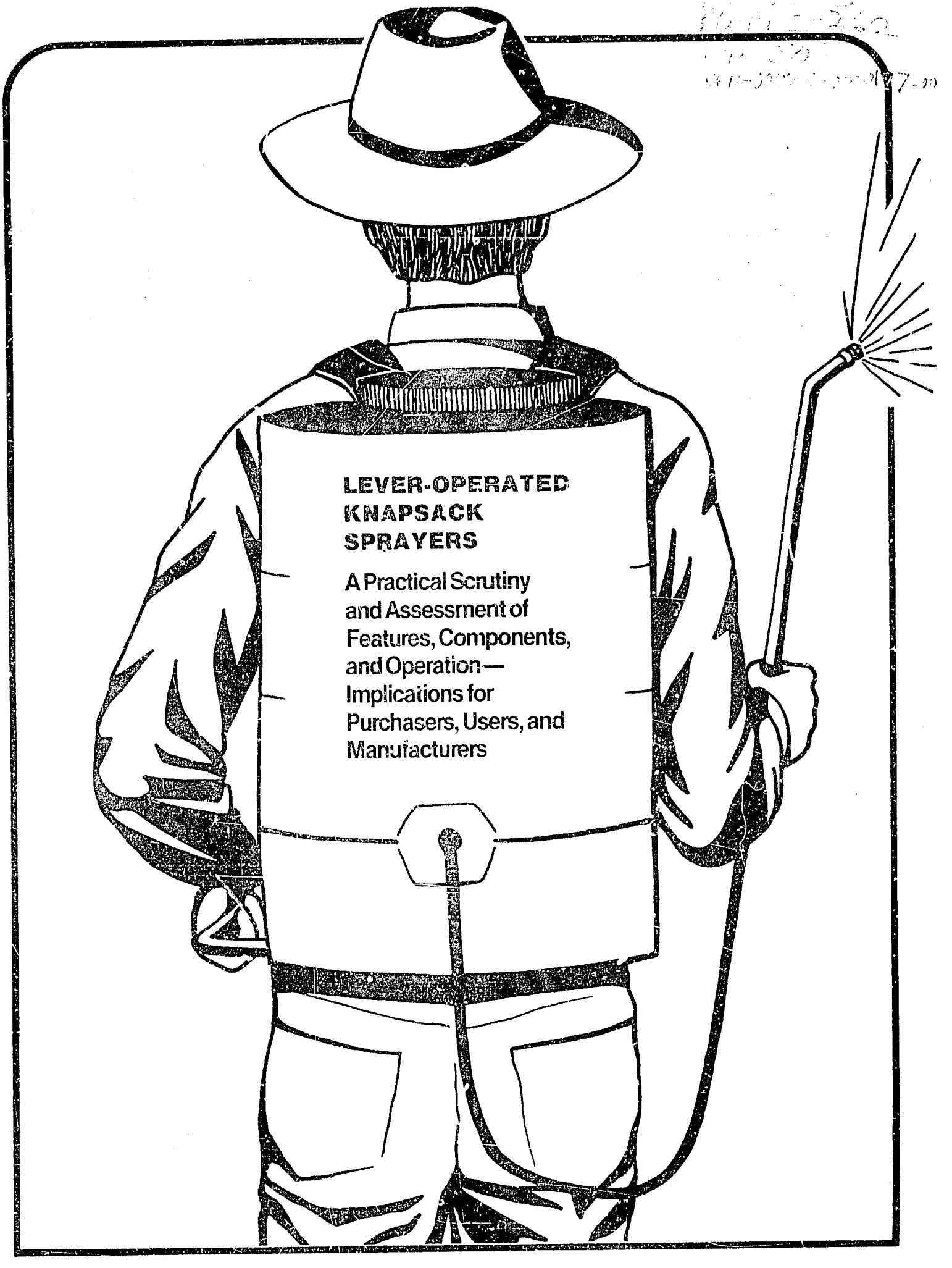
LEVER-OPERATED
KNAPSACK
SPRAYERS
A Practical Scrutiny
and Assessment of
Features, Components,
and Operation—
Implications for
Purchasers, Users, and
Manufacturers

International Plant Protection Center staff members examine examples of lever-operated knapsack sprayers collected and studied at Oregon State University.

The International Plant Protection Center (IPPC) was chartered at Oregon State University, Corvallis, Oregon (USA), in 1969 and assigned major responsibility for coordinating a weed management technical assistance and training contract between the University and the U.S. Agency for International Development.

IPPC has devoted its resources and energy to assisting governments, institutions, and agencies in developing nations to reduce the agronomic and socio-economic costs of weeds by advancing the effectiveness of these nations' weed control and vegetation management programs.

IPPC offers on-site technical agronomic assistance, socio-economic assessment, a variety of technical training, and broad information dissemination covering both terrestrial and aquatic weeds.

The aquatic macrophyte program is conducted through the faculty and extensive facilities of the Center for Aquatic Weeds at the University of Florida, Gainesville, Florida (USA).

LEVER-OPERATED KNAPSACK SPRAYERS

A Practical Scrutiny and Assessment of Features, Components, and Operation— Implications for Purchasers, Users, and Manufacturers

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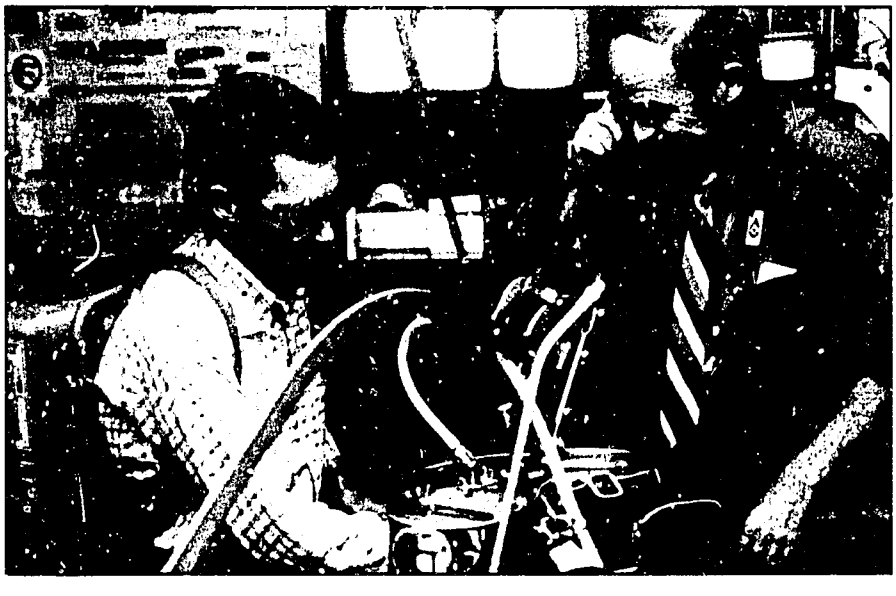


H.H. Fisher (left) and A.E. Deutsch share a lighter moment during sprayer assessment.

Acknowledgment

The entire lever-operated knapsack sprayer familiarization, scrutiny, and assessment program conducted by the International Plant Protection Center (IPPC) enjoyed impressive cooperation. Numerous manufacturers generously donated one, or in several cases, two or more machines to IPPC. Other firms helpfully supplied literature and specifications.

The U.S. Agency for International Development, through a long-running contract with Oregon State University (OSU) for weed management technical assistance, provided funds that helped support the program and publication of the results.

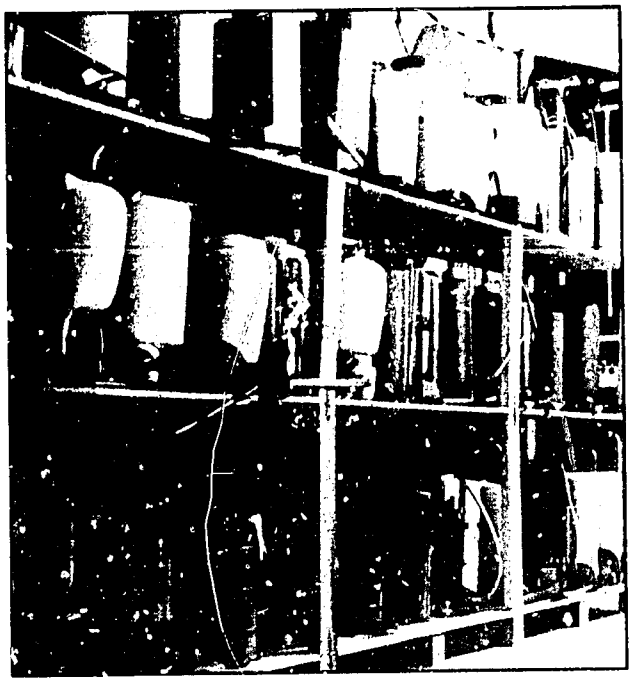
Our colleagues at IPPC and OSU were supportive throughout. In particular, we salute: S.F. Miller, IPPC director, for guidance and encouragement: co-workers at IPPC—weed scientists L.C. Burrill, M.D. Shenk, and A.S. Cooper—for insight and constructive suggestions; OSU students K. Tanphiphat and L. Noriel for thought-provoking questions and assistance during field testing; and C. Romo for sketches and line drawings.

The lever-operated knapsack sprayer program necessarily involved scrutinizing machines and judging their features, components, and operational capabilities. The observations that follow are strictly technical information and should not be construed as positive or negative reflection on the manufacturer. There are no direct comparisons offered, either between sprayers or against some predetermined standard; that was not an objective of the program.

Photos appearing in the text purposely avoid identifying manufacturer and product names. Inevitably, unique shapes or components of certain sprayers will cause them to be recognized by some readers.

Where the text mentions or illustrates less desirable features, or problems encountered, there is no intent to imply that a specific machine is, therefore, judged unsuitable. In fact, results from the program suggest that no "perfect" sprayer exists. Every one of the 37 units considered had one or more drawbacks and was less safe, or less versatile, or less comfortable than some other machine. But most units had numerous desirable, counterbalancing features that readily qualified them to fulfill the majority of spraying tasks appropriate for a lever-operated sprayer.

Illustration or mention of any product (or firm) in this publication does not constitute endorsement—nor does exclusion represent criticism, either intended or implied—by the authors, the International Plant Protection Center, the U.S. Agency for International Development, or Oregon State University.



Lever-operated knapsack sprayers at IPPC.

The views and interpretations expressed in this publication are the authors' and are not attributable to the U.S. Agency for International Development, nor to any individual acting in the Agency's behalf.

Finally, though many people generously provided helpful ideas and constructive comments, the ultimate responsibility for the end product is ours.

HHF, AED,
Corvallis, Oregon
July 1984

Foreword

Curiosity

There is a strong chance that you would not have read even this far if you were not either interested in lever-operated knapsack sprayers or curious about them, or both.

In fact, those two elements—interest and curiosity—plus some additional reasons, were impetus for staff members of the International Plant Protection Center to assemble an international collection of lever-operated knapsack sprayers in recent years. The experience, insights, and ideas that resulted from observing, using, and scrutinizing nearly 40 sprayer models were thought to be worth sharing. Hence, this publication.

Other publications, some fairly extensive (see: Suggested Related Reading), contain lever-operated knapsack sprayer information. However, none support a practical purchaser- or user-oriented viewpoint. The following pages attempt to do that and break new ground in world literature. They report the judged practical efficacy and safety of sampled LOK-sprayer features, components, and operation. Emphasis was intentionally placed on features, components, and characteristics of operation, not on specific machines or manufacturers, a reference point to bear in mind while using this publication.

The information presented may classify as "more than you ever wanted to know," about lever-operated (or any) sprayers, if considered in total. However, the intent was to offer a broad, if subjective, overview that could be useful in several ways to either organizations considering acquisition of multiple lever-operated knapsack sprayers, or to an individual verging on buying just one. Also, progressive manufacturers may be able to improve their product(s) based on the program's results. That could create marketing advantages for firms and, more importantly, indirect benefits for agriculture in general.

Using the Information

Extensive photos and drawings supplement the text. Together, they are intended as a guide to lever-operated knapsack sprayer integral features and components that warrant consideration, inspection, and trial. A more informed value judgment can hardly be avoided, particularly in the acquisition process. The section labeled "Scrutiny" poses a series of questions about: how well a lever-operated knapsack sprayer functions; what level of safety it provides: how "user-friendly" it is to the person whose back it will rest on; and, finally, how well designed and constructed it is overall.

The Introduction describes a lever-operated knapsack sprayer, fills in a bit of historical background, and sets forth the genre's advantages and disadvantages. Lastly, the authors cannot resist engaging in briefly musing about the generalities of what their experiences and biases suggest might be considered features of a "perfect" lever-operated knapsack sprayer.

Often the opportunity to choose from a wide selection of, or even between two, lever-operated knapsack sprayers may be impossible. Economics, governmental edicts, geographical realities, and other external constraints may limit or dictate the choice. But, to the extent possible, the adage "try before you buy" stands as the best method to judge competing products. Or, if an actual test is not feasible, a "hands on" visual inspection can be helpful. Even a review of specifications in product literature, without access to the actual sprayer(s), has merit. The question format utilized by this study can serve as a useful guide in any of the circumstances above.

Practicing with a lever-operated knapsack sprayer and multi-nozzle boom during a weed science training short course in Pakistan.

Introduction

What is a LOK-sprayer?

A tank, a pump, a means to actuate the pump, and a droplet-producing delivery system, all carried on a person's back, broadly describes a knapsack-style hydraulic energy sprayer. Ruling out those machines that include a small internal combustion engine to power the pump, the overwhelming majority transmit the operator's muscle power to the pump via a handle or lever. Thus, the breed has become known as lever-operated knapsack sprayers, abbreviated as LOK-sprayer in the following pages.

LOK-sprayers are commonly used to apply pesticides or other agricultural chemicals. The need for application arises from man's desire to protect his crops—representing food, feed, fibre, and livelihood—from an armada of antagonistic weeds, insects, and diseases.

From early crude attempts at manually applying pest-discouraging compounds to crop plants, technology rapidly progressed to hydraulic energy

spraying—that is, forcing liquid through a small orifice causing a solid stream to break up into droplets that provide far more thorough coverage of plant (or soil) surfaces. Sprayer development followed two basic paths: smaller, operator-carried units; and, larger machines that required a cart, wagon, or (later) motorized vehicle for transport. LOK-sprayers have been a mainstay of the former group.

One of the first large-scale uses of LOK-sprayers involved fungicide application to vineyards in France during the late 1880's. The machines of that era were heavy, cumbersome units with metal tanks. Though a far cry from contemporary LOK-sprayers in terms of material and sophistication, their basic operation was similar.

An IPPC staff member explains LOK-sprayer operations to participants at a weed science training short course in Kenya.

Advantages and Disadvantages

The lever-operated knapsack sprayer is a versatile tool that, with appropriate fittings, can apply herbicides, insecticides, fungicides, and other compounds. It permits application nearly anywhere a person can walk, or in areas often inaccessible to larger, motorized sprayers. It is useful for applying small or large amounts of material to areas, strips, spots, or individ targets. It is not a high capital cost item relative to other farming equipment. The majority, if regularly maintained and not severely misused, are sturdy enough to endure years of service. Their operation and physical characteristics allow use by persons with a wide range of physiques.

On the negative side, LOK-sprayers require large volumes of spray solution compared to controlled droplet applicators, or direct contact applicators (that use rope wicks or "sponge" surfaces) A LOK-sprayer, when filled with 18 liters of solution, can weigh upwards of 22 kg (48 lb), a substantial burden, particularly under tropical conditions, or when traversing rough terrain. In regions where the cost of a simple hoe or hand-tool is significant, the price of a LOK-sprayer may be prohibitive.

Unless appropriate compounds are available to use in them, LOK-sprayers are virtually worthless. Moreover, if improperly used, sloppily maintained, or poorly designed and constructed, a LOK-sprayer can constitute a hazard to the operator carrying it as well as to other humans, crops, animals, and the environment in general.

Evidence suggests that LOK-sprayers, long employed in tropical plantation agriculture, will continue to be an important tool for developing nations. In more developed regions, LOK-sprayers are

becoming more prevalent on small farms, in nurseries, and in forestry; they are also utilized for agricultural research and extension. The LOK-sprayer configuration has weathered many decades; it is anticipated that, in one form or another, the concept will continue to serve well into the future. More than 80 firms worldwide currently construct and market at least one model of LOK-sprayer, according to IPPC files.

Anatomy of a LOK-sprayer

Figure 1., a simplified schematic, represents most of the basic components of a LOK-sprayer. After spray liquid is poured through the **basket strainer** into the **storage tank**, the **tank cap** is replaced and secured. The full LOK-sprayer is then positioned on an operator's back, secured by **carrying straps.** With full LOK-sprayer in place, the operator grasps the **pump actuating lever** (or handle) in one hand, and the **control valve handle (or trigger)** in the other and begins to move the lever in a vertical pumping motion. The movement actuates a **pump** which propels liquid past a **one-way valve** and into a **pressure or surge chamber** (not shown). The **hose** connects the surge chamber and the **wand/lance.** When the operator opens the **control valve** near the **handgrip** on the wand/lance, pressure forces liquid to flow past the valve, through the wand/lance, and exit through the **nozzle** (into the atmosphere) as a pattern of droplets, or spray.

Up to this point, there is a uniformity in LOK-sprayer design. Beyond the basics, however, machines from various manufacturers display variation in their approach to liquid storing, pumping, and spraying. The emergence and development of blow-moulding man-made materials in recent years appears to be the major change, as many manufacturers now offer lighter-weight, chemically resistant "plastic models." Use of in-line strainers has increased. More attention has been paid to constructing units with curved tanks, or which include some sort of back (lumbar) brace, both aimed at making LOK-sprayers more comfortable to carry and operate. Similarly, wider carrying straps with more padding improve weight distribution and thus comfort.

Another technological trend involves more firms fitting their LOK-sprayers—as standard equipment—with nozzles suitable for herbicide application. Interchangeable nozzles increase sprayer versatility and efficiency.

Regional preferences and traditions have emerged. In Southeast Asia, for example, over-the-shoulder pump levers are more popular than the under-arm style found elsewhere. A second case involves the type of pump used. Though LOK-sprayers traditionally employed piston pumps, diaphragm pump use has increased significantly in the European region.

A Practical Look at LOK-sprayers

The ubiquity and importance of the LOK-sprayer has not gone unrecognized in regard to evaluation. For many years, the Overseas Spraying Machinery Centre in the U.K. (now part of the Silwood Centre for Pest Management) has performed exhaustive "torture" tests on LOK-sprayers (and many other types of sprayers) to assess durability, performance, and chemical compatibility, among other aspects. More recently, the Agricultural Spraying Machinery Evaluation Centre in Thailand has taken the same approach. Both organizations have utilized specially designed equipment to conduct tests, or chemical compatibility studies, under laboratory conditions.

Often the U.K. testing has been commissioned by manufacturers themselves; thus, certain results were treated as proprietary, not public, information. However, both U.K. and Thai centers have published selected test-derived facts concerning long-term durability, chemical compatibility, and other technical data.

While the public release of test results was useful, a lack of readily available, practical, user-oriented LOK-sprayer information became apparent. Questions as fundamental as, 'On what basis would a prospective purchaser select between two or more machines?', or, 'What features should be carefully scrutinized and what characteristics avoided?', needed answers. These and other guiding questions had not been discussed extensively.

Published reports concerning LOK-sprayers contained few impartial reviews and technical discussions of their components, features, and operations, particularly related to field usage. To address this need, and provide information for its own programs, the International Plant Protection Center utilized a random cross-section of LOK-sprayers to consider:

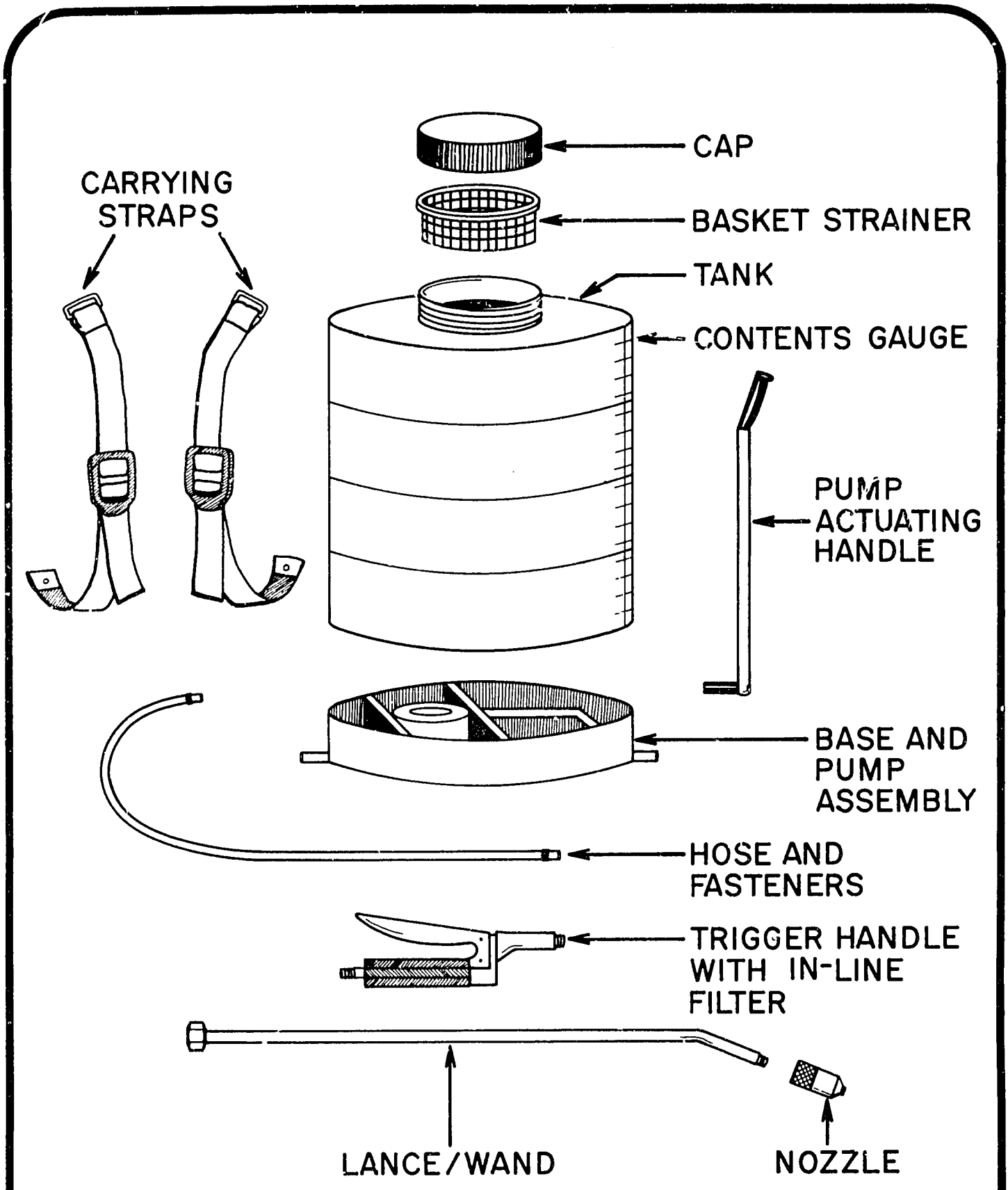
1) **operating efficiency;**
2) **ergonomics;**
3) **safety; and,**
4) **overall design and construction.**

The Objectives of the Study

The broad objectives of the IPPC effort were:

* to help persons engaged in agricultural practice, research, and extension—particularly in developing countries—make a more well-informed choice when considering a LOK-sprayer purchase;

* to become a more extensive LOK-sprayer information resource for the U.S. Agency for International Development, its various missions, bureaus, and departments;



Simplified schematic of LOK-sprayer components.

* to serve as an information source for LOK-sprayer manufacturers as product development and improvement occur;

* to provide current LOK-sprayer owners-users with additional information that might increase the utility of, and benefit from, their machines; and,

* to increase IPPC staff members' knowledge about the LOK-sprayer as an agricultural tool.

The Approach

The IPPC approach aimed at offering:

1. **Practicality:** the underlying philosophy was focused predominantly on LOK-sprayer performance under conditions approximating those found in the field.

2. **Consistency:** all 37 LOK-sprayers that composed the sample were scrutinized and field tested under equivalent conditions by the same scientist.

3. **Usefulness:** together, the questions posed, the illustrations shown, and the commentary offered are intended as a usable information resource for those individuals or organizations considering LOK-sprayer acquisition (and others interested in LOK-sprayers), regardless of the availability of published information on a particular sprayer or the specialized laboratory equipment to extensively test it.

The information generated furnishes neither durability nor chemical compatibility data, and, by intent, omits specific brand or manufacturer names as well as specific model recommendations. The ultimate purchase decision rests, most naturally, with the buyer.

The Procedure

The LOK-sprayer assessment program at IPPC began rather casually, though eventually 37 units, representing 24 manufacturers in 15 nations, were scrutinized and field tested. The group comprised a random sample of machines generously donated by some manufacturers, plus others purchased by IPPC. No concerted effort was made to attain geographical (or other) balance or representation.

Because IPPC has conducted the AID-OSU weed control research and weed science training program for 15 years, the LOK-sprayer study emphasized, but was not limited to, each machine's herbicide application performance. Therefore, LOK-sprayers were fitted (where possible) with the same single standard flood nozzle (also termed impact, or reflex nozzle) as generally used for broadcast herbicide application. Thus, spray output was determined under nearly equal conditions, where feasible.

As mentioned, no stress or long-term durability tests were conducted. But each of the 37 units was carefully observed, studied, and put through basic field operations using water only. For instance, each sprayer was filled with water using a pail that produced a wide stream of liquid, as is often the case under field conditions. LOK-sprayers with a smaller diameter tank (filler) port handled the wide stream less safely and efficiently than those with a larger diameter port.

For another test, each sprayer was filled to capacity with water and its cap replaced and secured; the unit was then abruptly knocked over to simulate accidental mis-handling. Results revealed serious safety problems with some filler port cap designs. Similarly, another simple procedure involved an operator bending over with a full LOK-sprayer secured on his back. Tank breather ports on some units allowed liquid to be ejected onto the operator's head, neck, and back—clearly an unsafe design.

Subjective judgments were made about each unit's overall design. Design, in this case, included construction features; ergonomic considerations were treated separately. Many units exhibited certain features that either were not well thought out, or were inconsiderate of operator comfort and ease of use.

Steps were taken to maintain impartiality during scrutiny and assessment. Each LOK-sprayer was marked with an identification number and subsequently referred to by that number. No reference to manufacturers, brand names, or models appears in the following pages. Even though some sprayers outperformed others, direct comparisons were avoided to the extent possible. The entire exercise aimed at generating new, usable information, including advantages and disadvantages generally inherent in LOK-sprayers.

Information was developed by using a standard list of questions prepared after conducting a trial based on an initial assessment of 19 LOK-sprayers. The questions ultimately were grouped into four categories as mentioned. Scrutiny, field testing, and assessment of LOK-sprayer features and components were performed by the senior author to maintain uniformity.

The Outcome

The scrutiny and its results are structured as a series of questions a potential LOK-sprayer buyer might ask before making a purchase. In some cases, comments precede or follow the questions. The four categories within the Scrutiny section are broad and, inevitably, tend to overlap.

Photos and drawings are used extensively to help graphically depict the LOK-sprayer characteristics and components being discussed.

The Scrutiny

I. Operation ..... how well it works

A LOK-sprayer, just as most any other device man uses, should fulfill its intended role. If it cannot perform the function it was designed for, or can only do so in an inefficient or unsafe manner, then its usefulness is severely reduced. Failure to perform, or an obvious lack of reasonable safety, cancels the need to consider any other aspect.

All the LOK-sprayers studied were able to accomplish the basic functions of storing, pumping (compressing), and spraying liquid. But there were marked differences in their individual efficiency and smoothness of operation—and there were mechanical failures.

To begin the scrutiny, the scientist/tester developed general familiarity with each machine in the field. This phase involved numerous operational aspects—from filling each unit with water, to determining sprayer output by precise spraying of a measured area.

1. Tank capacity

- *Is the tank capacity matched to the intended task?*

LOK-sprayers' tank capacities mainly range from 12 to 20 liters (3.2 to 5.3 U.S. gallons).

While a smaller capacity tank means the operator carries less weight, it also can cause more frequent spraying halts for refilling than a larger tank would. More refilling also may cause more non-productive time spent walking to and from a water source. Additionally, more occasions for mixing and handling equate with increased exposure to potentially harmful pesticides.

2. Pump capacity and operation

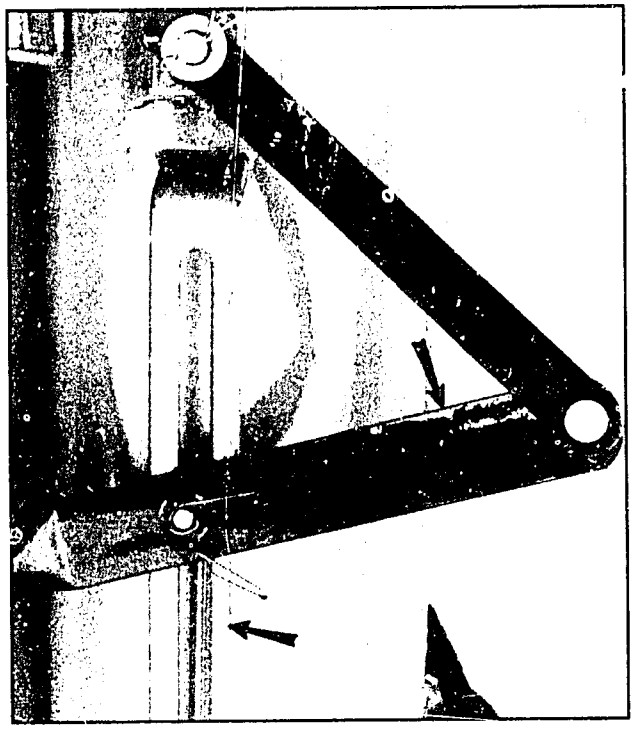
- *Can the pump develop sufficient output or delivery to meet anticipated needs?*
- *Are pump volume, stroke, and pressure developed adequate to produce the desired output?*

Obviously, more output is required to operate a 3-, or 4-nozzle boom satisfactorily than a single nozzle. Multiple-nozzle booms are extremely convenient for certain spraying operations by reducing number of passes, time required, and cost.

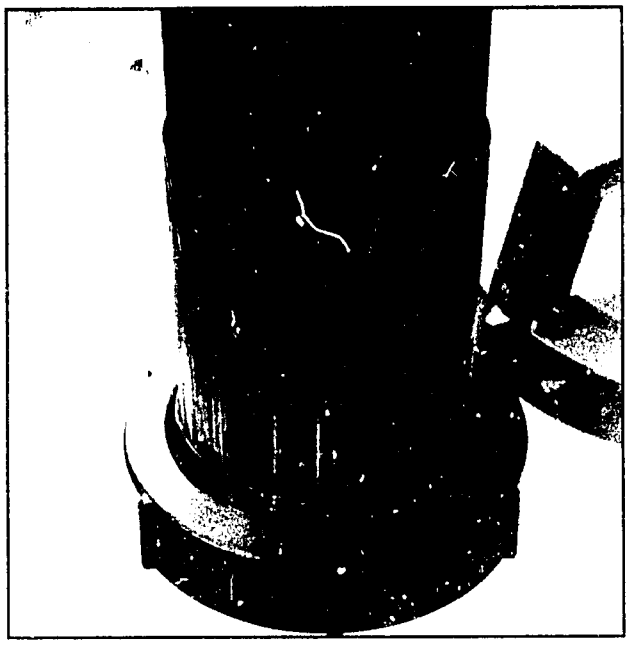
- *Does the pump operate at maximum efficiency?*

A pump's efficiency largely depends on its displacement, and complete seating—or sealing—of its valves, washers, O-rings, and other components. If possible, the pump mechanism should be examined for potential problems or shortcomings.

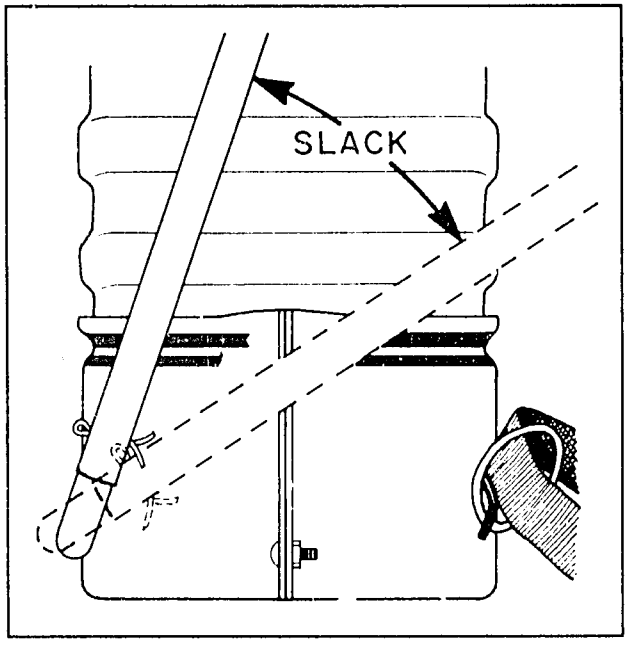
- *Is there excessive friction in pump linkage, or between pump cylinder and collar?*
- *Does linkage strike any part of sprayer, or rub against operator?*
- *Does linkage have excessive looseness or free play?*



Worn areas (arrows) indicate excessive friction on lever arm and vertical guide.



Multitude of marks on pump cylinder reveal excessive friction.



Slack, or free play, in lever arm decreases pumping efficiency.

Of all the elements of a LOK-sprayer, the pumping action and linkage are among the most important to the operator. Binding or excessive "play" in the linkage can be physically tiring and psychologically counter-productive for the operator and can accelerate sprayer malfunction.

Pumping Considerations

Is a piston pump or diaphragm pump best? A piston pump (positive displacement) usually produces more output than a diaphragm pump, but the latter often requires less energy for operation and less maintenance. Diaphragm pumps generally resist wear better than piston pumps when using wettable powders.

To gain a sense of comparative output, a single flood nozzle was fitted to 29 of the 37 LOK-sprayers; the other eight could not be easily adapted. The average flow rate for the 29 was 1,977 ml/min (.52 US gal/min) at 51 pump strokes/min. Only five LOK-sprayers (of the 29) varied considerably from this average.

Based on field experience, pressure in the range of 2 to 3 bars (approximately 2 to 3 kg/cm², or 30 to 45 lbs/in²) supported operation of a 4-nozzle boom. While most of the 29 LOK-sprayers produced this pressure, some did so only with excessive, nonsustainable operator effort.

- *Can uniform pressure (and output) be maintained even as the liquid level in the tank approaches zero?*

Some LOK-sprayers experience problems; pressure declines noticeably as the liquid level in the tank drops, leading to nonuniform application. To avoid this effect, the operator inconveniently would have to stop spraying, remove the LOK-sprayer, and either refill the tank, or cope with safely disposing of the remaining unsprayed solution. The operator can usually observe this pressure drop, either by a deteriorating (weaker) spray pattern or by increased pumping effort to maintain pressure.

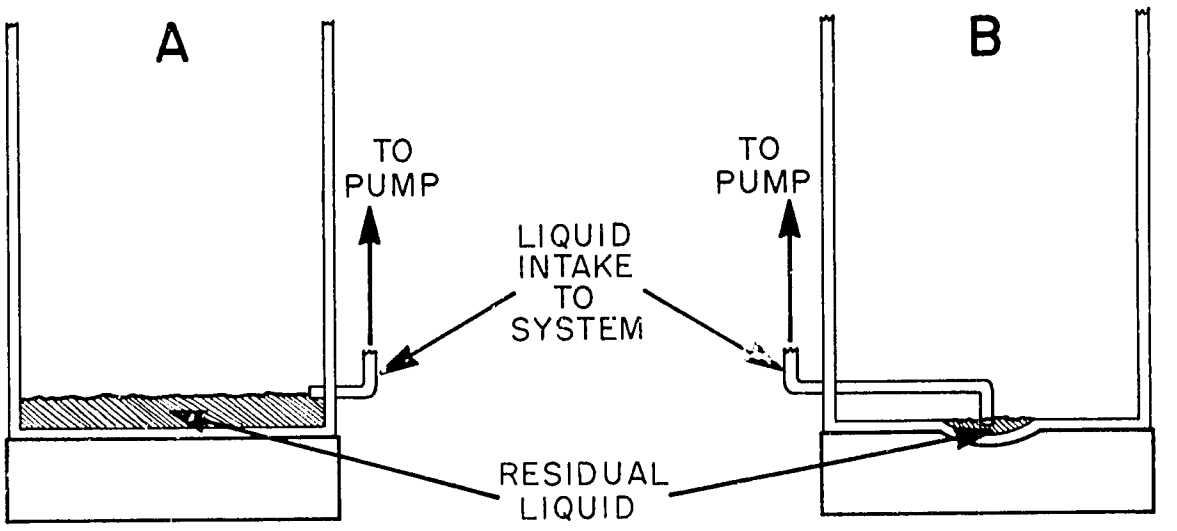
3. Pressure chamber

- *Does surging or pulsing (unsteady pressure) occur at each pump downstroke?*

Failure to hold a steady pressure occurs if the pressure (or surge) chamber is too small in relation to pump volume. Uneven application results. Surging can be observed by spraying water on a dry, smooth, hard, horizontal surface. Steady spray pressure creates a continuous wet band, or swath, whereas surging produces "bars" across the path of spraying that remain visible (wet) after sections between the bars have dried.

- *Does a considerable amount of liquid remain in the tank, pump, surge chamber, and hose when the pump stops delivering liquid and allows air to enter the system?*

Most LOK-sprayers do not pump out all spray solution. A small amount of residual liquid is acceptable; a lot is not.



The liquid intake system and design of tank "A" cause excessive residual spray liquid, whereas tank "B" leaves very little.

II. Ergonomics ..... how well it "fits"

While a LOK-sprayer's basic operation is important, so is its "feel" to the person who "wears" it, the relationship of operator to machine known as ergonomics. If, for example, a LOK-sprayer is exceedingly uncomfortable for an operator to wear on his back, difficult to pump, or unwieldy to operate, spraying efficiency will suffer. Or, necessary spray applications may be foregone altogether.

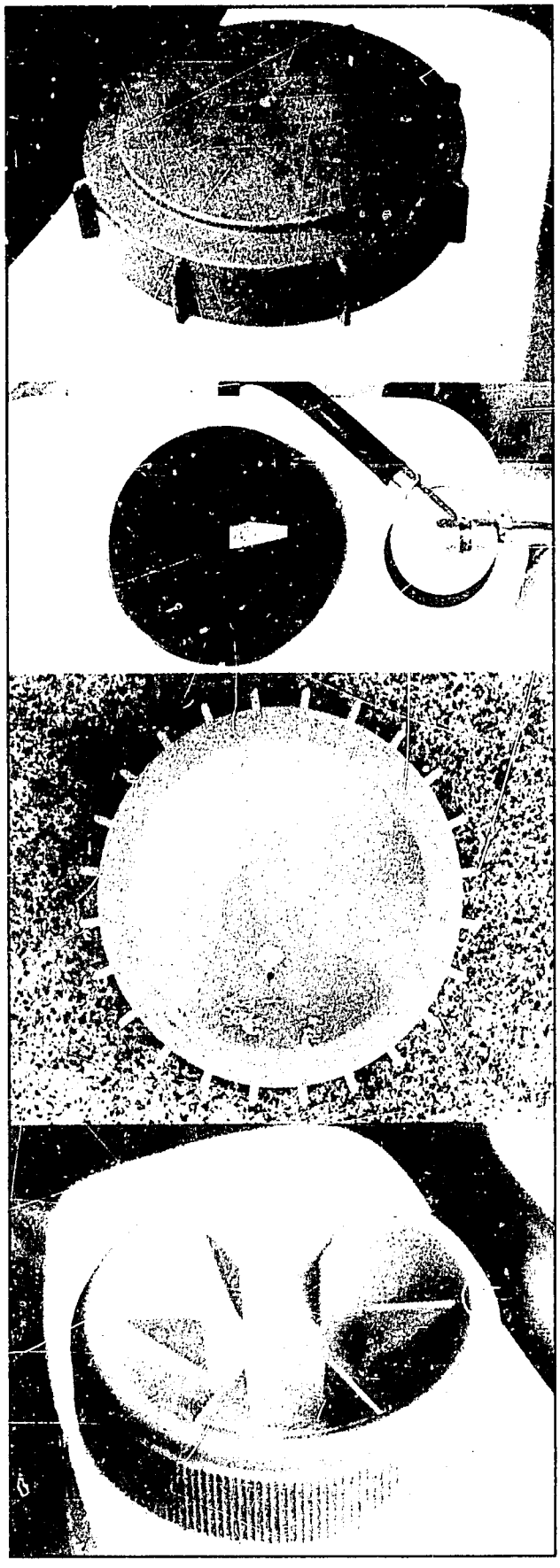
A LOK-sprayer, holding steady pressure and free from surging, produces a continuous, even spray pattern. In this photo, the multi-nozzle boom is positioned unusually close to the target surface to accentuate spray pattern visibility.

A LOK-sprayer needs to be reasonably comfortable to wear and easy to pump while producing satisfactory output at a sustainable level of human effort. Also, controls should be readily accessible and operable. Efficiency will increase the more an operator and LOK-sprayer blend into an integral, harmonious unit.

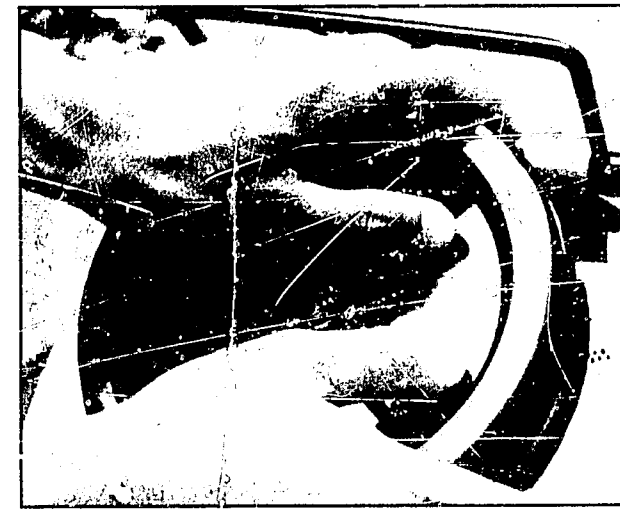
1. Tank shape and contruction

- *Does the shape of the tank conform to the operator's back?*
- *Are back (lumbar) supports or padding provided?*
- *Is there provision for air flow between the operator's back and the tank surface?*

Grooves cast into the tank provide for air flow between the tank and the operator's back.



Protrusions, handles, and knurling facilitate grasping, tightening, and loosening caps.

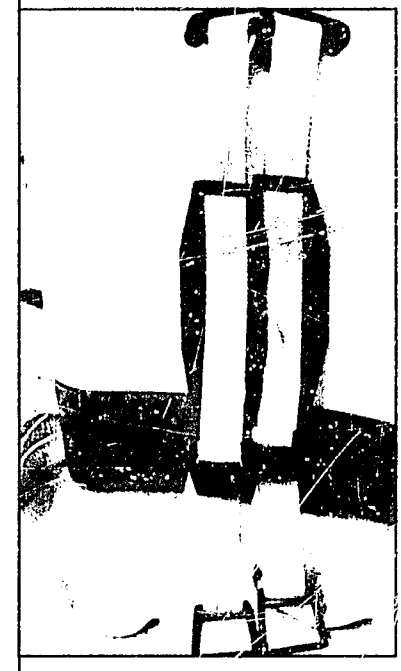


Location of the carrying handle and cap on this LOK-sprayer can cause pinched fingers.

- *Does the shape, size, and position of the tank cap make it easy to grip, remove, and replace?*

2. Tank straps

- *Are shoulder straps firmly anchored (at their upper end) to the LOK-sprayer? Are straps attached at proper angle to conform to operator's shoulders?*



Straps attached at a sharp angle (above) cause discomfort to the operator.

At left, easily adjusted, securely attached straps.

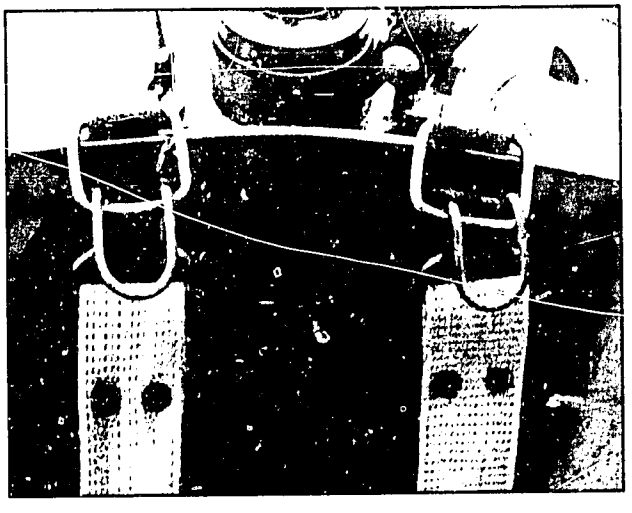
- *Are straps wide enough to evenly distribute a full sprayer's weight, or narrow so that they dig into the operator's shoulders? Are straps padded?*
- *Are straps readily adjustable to fit various shapes of different operators?*

- *Are straps easily secured when shouldering a full sprayer?*

If possible, investigate these points: fill the LOK-sprayer with water and put it on. Attempting to swing a full 22 kg (48 lb) LOK-sprayer, with poorly designed strap attachments, up onto one's shoulders and secure it— while grasping the wand/lance in one hand to keep the nozzle from becoming plugged with soil—can be an eye-opening and exasperating experience.

- *Are straps easily detached?*

Quickly detachable straps are a convenience as well as a major safety factor in the case of accidental contamination by pesticide.

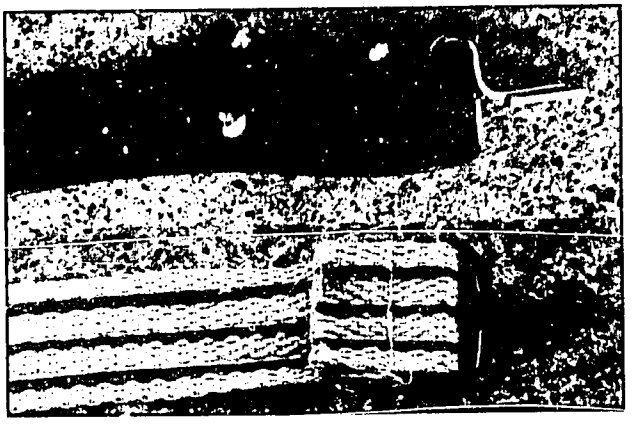


Easily adjusted strap system uses a quick-pull "D" ring arrangement.

Strap-end clip is easily hooked over knob integral with plastic tank.

Unsecured, bent wire hooks often fall off (upper) rings when the operator attempts to put on full sprayer. Note rusting strap rivets and use of absorbent material for straps.

Straps with very little adjustment (top) and zero adjustment.

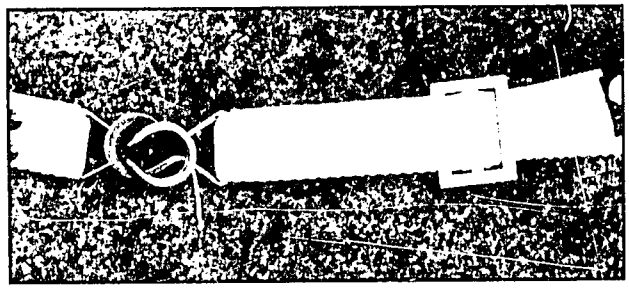


* *Is a waist strap provided to help anchor the sprayer and reduce bouncing?*

This is especially important as spray solution is used and weight of the contents declines. A sprayer that bounces, chafes, or bumps the operator's back is annoying. Also, an unsteady sprayer may allow air to enter the pumping system prematurely causing nonuniform application. A well-balanced LOK-sprayer may not need a waist strap.

Sprayers without a waist strap may bounce and bump on the operator's back.

An effective, quick attach/detach waist band clasp.



3. Balance

* *When grasping the full LOK-sprayer by the straps and lifting it, does it tend to drastically tip or pivot?*

* *Does the LOK-sprayer feel balanced on the operator's back when full? When partially full?*

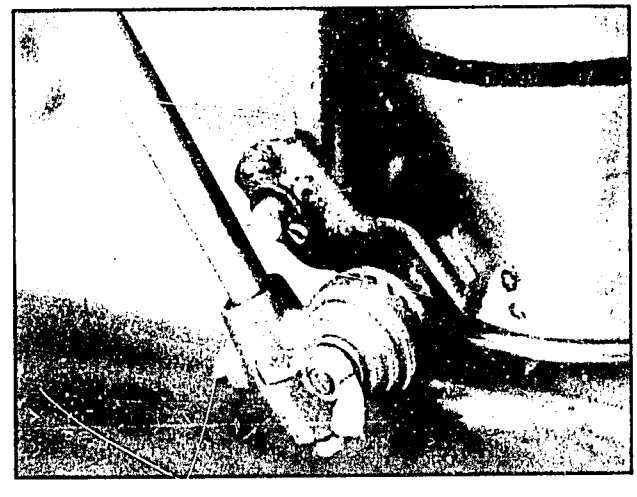
Strap attachment location, tank shape, and location of components influence sprayer balance. Strap upper ends should be attached near the sprayer's top. A desirable low center of gravity results when the heaviest mass of the sprayer and bulk of spray solution are placed relatively low and close to the operator's body, in relation to the overall weight. Some LOK-sprayer tanks are purposely wider (or bulged) at the base—and contoured to fit the operator's back—to increase balance and stability.

A tank bottom bulge helps lower the center of gravity and increase stability.

4. Lever arm

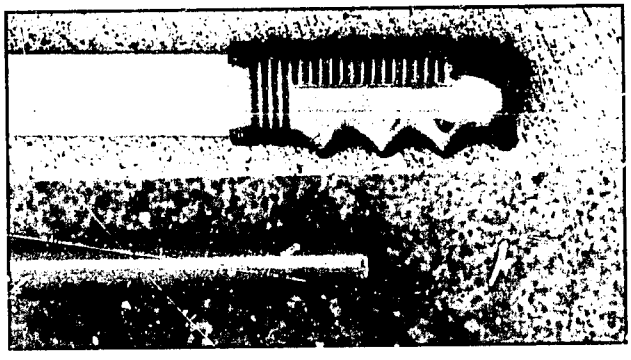
* *Can lever arm be used on either side of the LOK-sprayer to meet the operator's preference for right-, or left-hand pumping, or for switching between sides to reduce fatigue?*

* *Is lever travel (or stroke) efficient?*



Toothed cogs and wing nut allow adjustment of lever positioning; lever arm length can be adjusted by a set-bolt and collar. The assembly can be quickly transferred to the opposite side so the operator can switch to his other arm for pumping.

- *Does lever readily "fall to hand" at an appropriate position for maximum comfort?*
- *Is lever arm shaped so as to minimize pumping effort?*
- *Is the lever handgrip (if present) shaped and located for comfort and easy grasp?*



Handgrip (top) was more comfortable than many others.

An excessively curved and awkwardly positioned lever chafed against the operator.

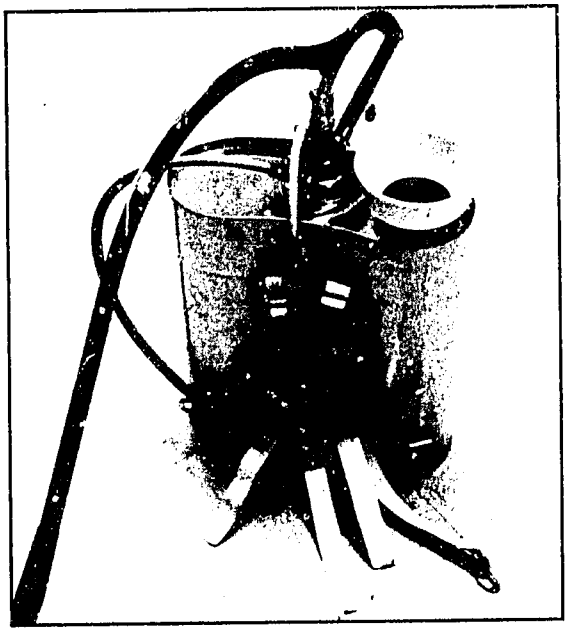
At right (above), an over-the-shoulder lever arm and (below) an under-arm lever LOK sprayer.

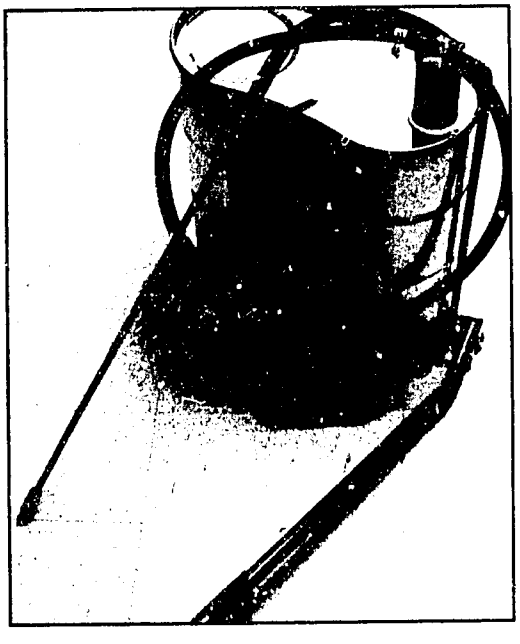
5. Pumping effort

- *Does the pump stroke (either up or down) produce sufficient pump output?*
- *Is the effort required for pumping sustainable over long time periods?*

Which lever is best?

Is an over-the-shoulder (O-T-S) lever arm more energy-efficient for an operator than an under-arm lever? Seemingly, it's a matter of individual preference, also relating to culture and familiarity. The O-T-S position allows an operator to easily switch from right- to left-hand pumping, and to move through tall, closely-spaced plants more readily than an under-arm lever. Some experienced LOK-sprayer users believe that an O-T-S lever is less tiring to use for large-area spraying. However, the long, curved O-T-S lever arm can be an inconvenience during filling, emptying, and transporting a LOK-sprayer. Also, an O-T-S configuration usually operates only piston pumps and may not be suitable for diaphragm pumps.



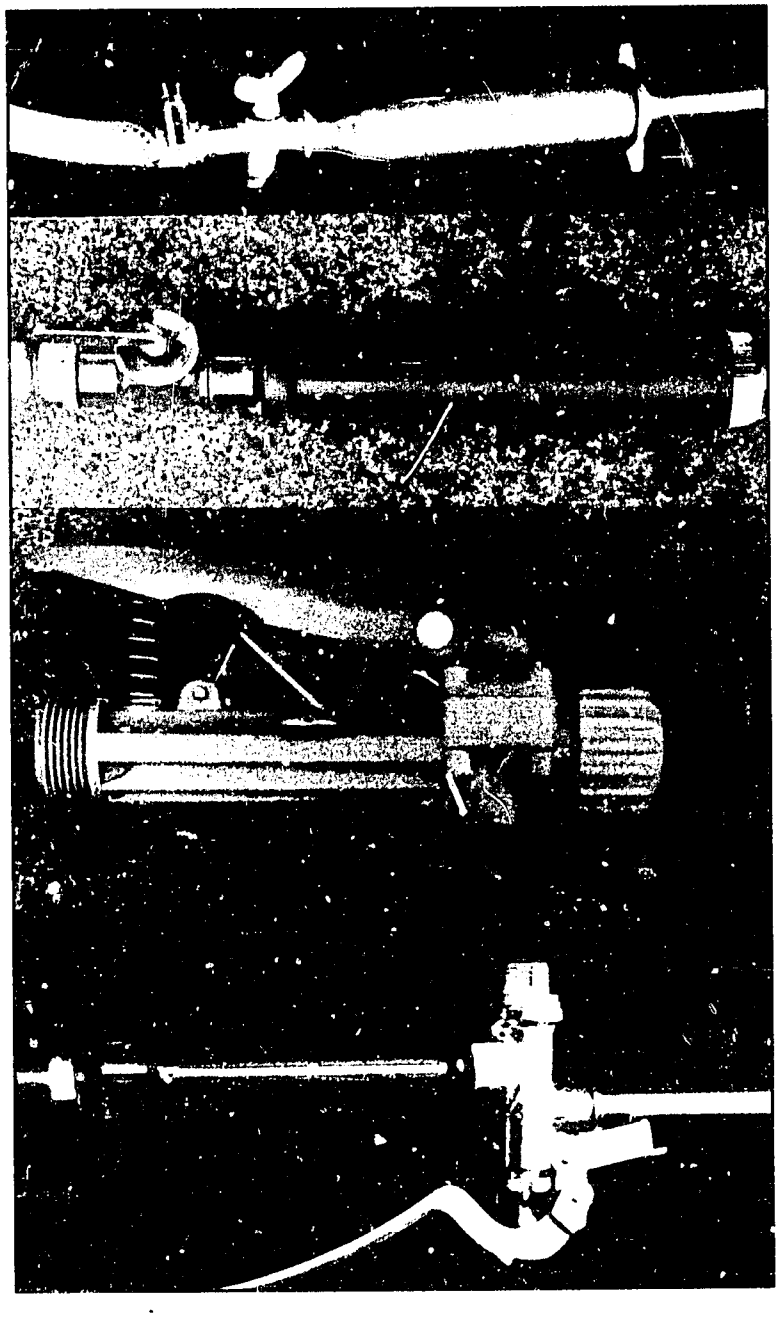


6. On/off control valve

- *Is the control valve conveniently positioned for the operator?*
- *Can valve easily be activated, locked, unlocked, and deactivated with one hand?*
- *Can operation of valve be sustained without rapidly fatiguing the operator's hand?*

7. Lance/wand

- *Is the lance/wand balanced well enough to prevent rapid operator fatigue?*
- *Does its length allow for a comfortable hand position during application?*
- *If a pressure gauge is fitted, is it positioned for easy viewing and good balance?*



Four on-off control valves (with inflow hose at left in each case): the valve (at top) is awkwardly positioned behind the handgrip forcing the operator to release and relocate one (or both) hand position(s) to open or close the valve. The next valve is also behind the handgrip, but more easily operated than the first valve. The next valve, using a squeeze lever, allowed quick one-handed operation, but its fluted surface was uncomfortable and its heavy spring caused excessive hand fatigue. One of the smoothest, most efficient valve controls (bottom) was comfortable to operate, easy to lock open and release, and least fatiguing. Note plugged opening provided for pressure gauge installation.

III. Safety ..... how safe to use

Anyone storing, handling, mixing, or applying pesticides faces a certain hazard level. The degree of hazard varies widely depending on the specific pesticide involved, the operational procedures employed, the prevailing environment, the precautions taken, and the equipment used.

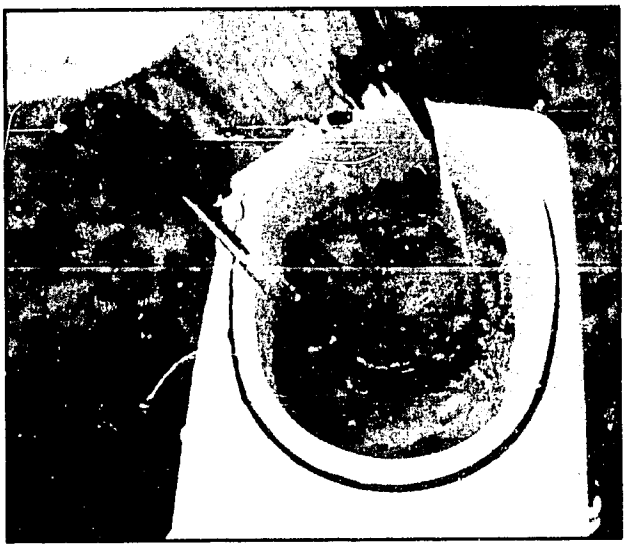
Any piece of pesticide application equipment requires regular maintainence to be kept in acceptably safe condition. However, observations made during the scrutiny of 37 virtually new LOK-sprayers revealed potential safety problems in some units.

During use of a LOK-sprayer, the operator can be exposed to physical injury or, more serious, pesticide contamination. Thus, design and construction features that could cause unsafe conditions should be a significant influence on the buying decision.

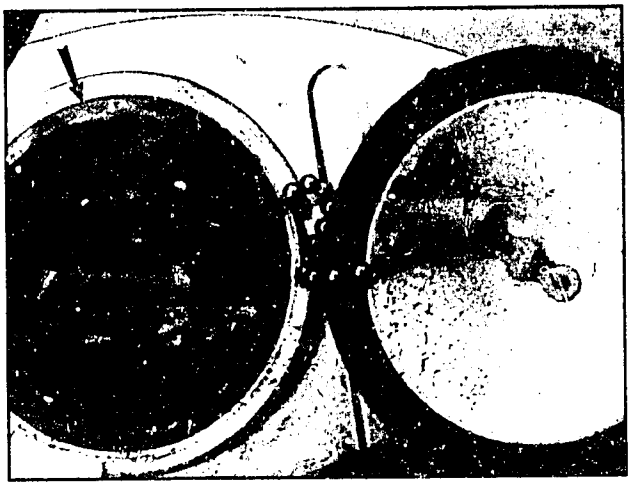
1. Filling/emptying

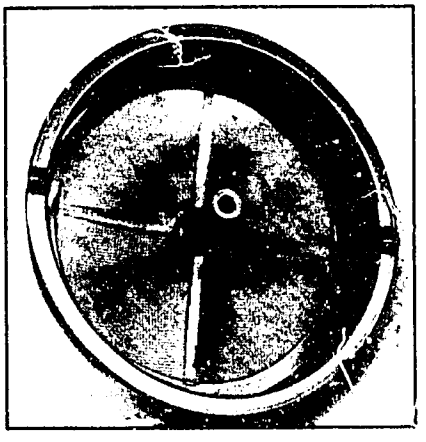
Does liquid splash up (and out) of the tank port during filling?

- *When removing or replacing the basket strainer, can the operator avoid direct contact with spray solution?*
- *Does an air lock or bubble develop, while pouring liquid into the tank, causing the operator's fingers to contact spray solution while freeing the strainer?*



A large tank port (above) decreases splash and expedites filling. Below, a built-in funnel, though increasing the diameter of the entry, can cause an air lock resulting in overflow and increased operator exposure to spray solution.

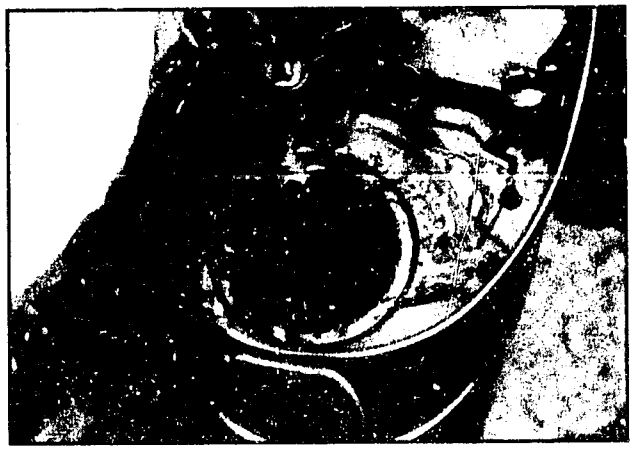




The basket strainer (above left) binds in port (arrow), is difficult to remove, and has no easily grasped projection, possibly causing the operator's fingers to contact spray solution. Below, this basket strainer has a center post (with built-in air vent) that aids removal and helps the operator avoid contacting spray solution.

- *What happens to poured liquid that misses the tank port? Is it contained? Rechanneled back into the tank? Or does liquid overflow and cause contamination?*

Some LOK-sprayer tanks incorporate a lipped or funnel-shaped top that helps contain spilled or sloshed spray solution.



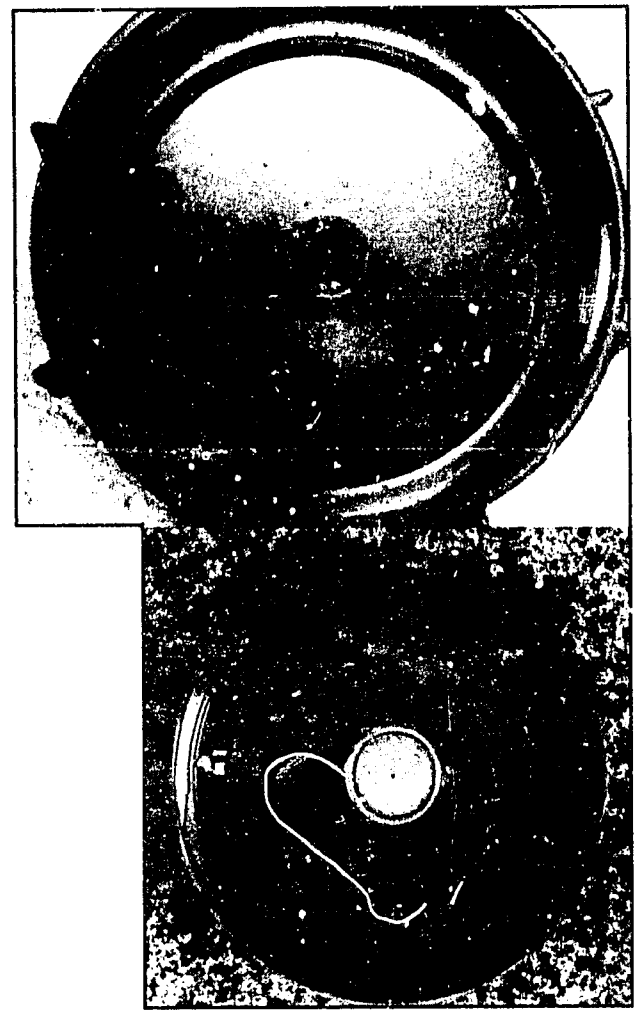
A small tank port causes splashing; however, a rim around the tank's top channels overflow back into tank.

- *Can liquid residue be easily poured out of the tank when spraying is completed?*
- *Does any liquid remain trapped inside after the third attempt to pour all unused solution out of the LOK-sprayer?*

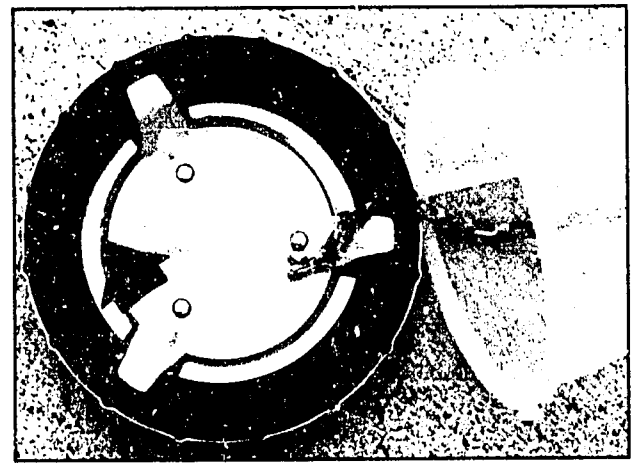
Leakage can occur around the pump cylinder.

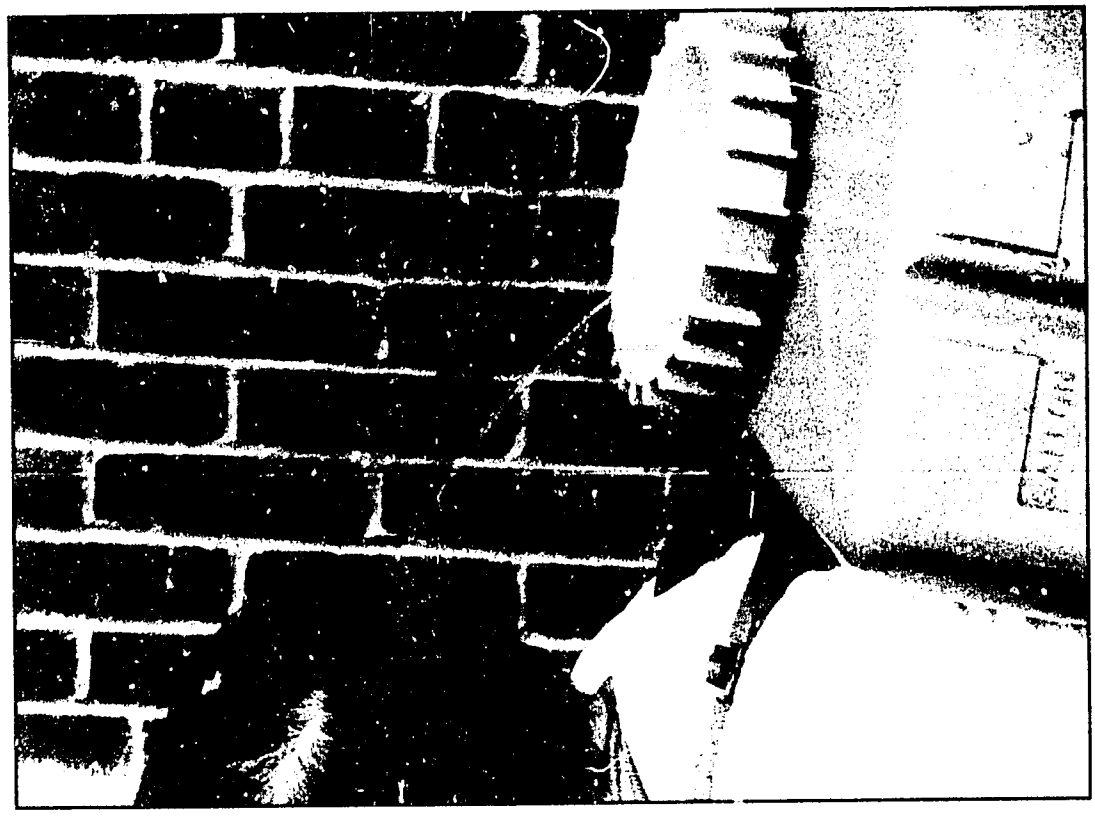
2. Leakage

- *Does leakage occur around tank port and cap during normal operation? At pump cylinder, or at pump fittings?*
- *Does filler port cap have a gasket and sealing lip?*



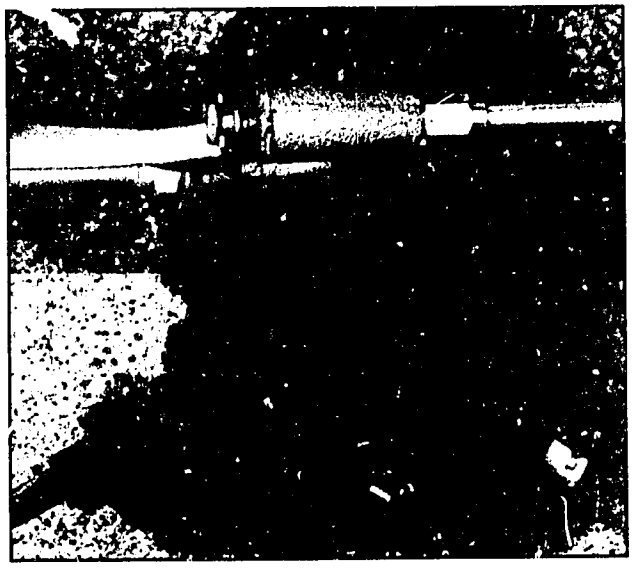
Underside views of tank port covers show: (top) sealing lip but no gasket, plus large diameter—though offset—breather port; (middle) sealing lip, gasket, and smaller diameter breather; (at bottom) cam-type cover with a large, effective gasket, a shielded breather port-cum-diverter (arrow), and a security chain.





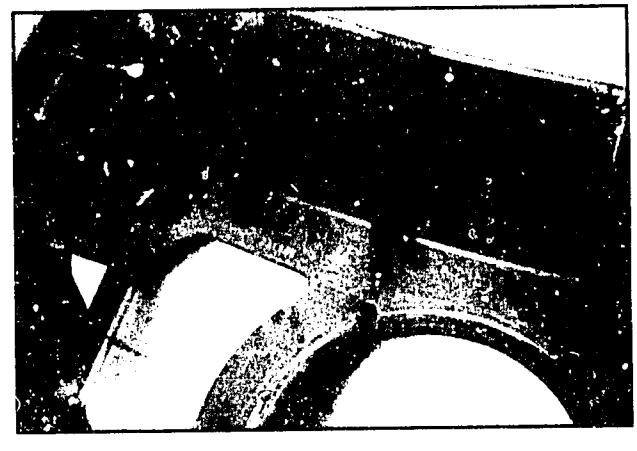
If the operator bends over while carrying any of numerous LOK-sprayers when full, a jet of spray solution spurts out of the breather vent in the tank port cap onto—and possibly causing serious contamination of—the operator.

- *Does breather mechanism—that allows air into the storage tank to relieve a potential vacuum in the tank—incorporate a spring-loaded valve, or port with diverting feature, to prevent leakage, even if the operator bends over while carrying a full LOK-sprayer?*
- *Do any of the hose, lance/wand, or control valve connections leak? Can leaks be stopped easily without special tools?*
- *Does control valve provide positive, drip-free shut-off?*



Not only would leakage past the control valve pose a hazard to the operator, the resulting drips could cause unwanted plant injury, harm other people or animals, and waste spray solution.

- *Can solution accumulate anywhere on the exterior of the LOK-sprayer (such as within the tank skirt) to be released onto the operator later?*



The skirt from a disassembled sprayer reveals stains of dried pesticide that was trapped inside and later could have been released onto the operator.

At left, a leaking on-off valve (top) and a press-fit wand swivel that popped out of its housing both were potential sources of operator contamination.

Leather straps and compostion shoulder pads can absorb pesticide and become a source of operator contamination.

3. Materials

- *Are nonabsorbent materials utilized throughout?*

Straps, strap pads, back supports, and other "soft" items should be checked to see that they resist pesticide absorption and accumulation.

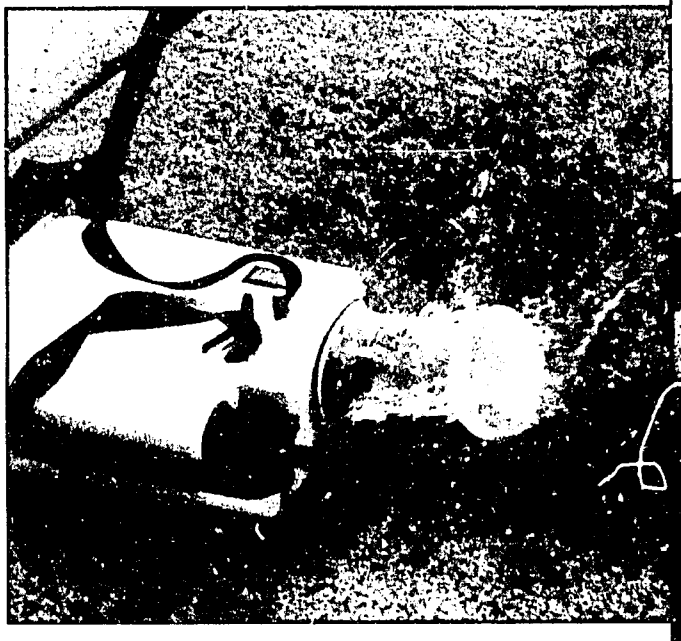
4. Design

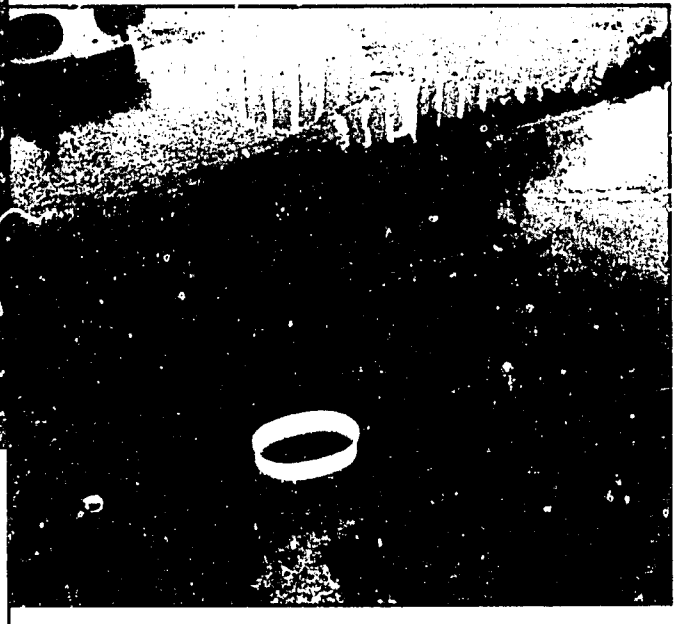
- *Are the LOK-sprayer's various components all designed to safely withstand accidental mishandling?*

The filler port cap should remain fully secured even when the completely filled LOK-sprayer is tipped over. A snap-fit style of cap has been found to be less secure than a screw-on or cam-lock type cap.

The control valve should be constructed so that solution is released only when the operator opens the valve, and not accidentally when the lance/wand is dropped or the valve handle bumped.

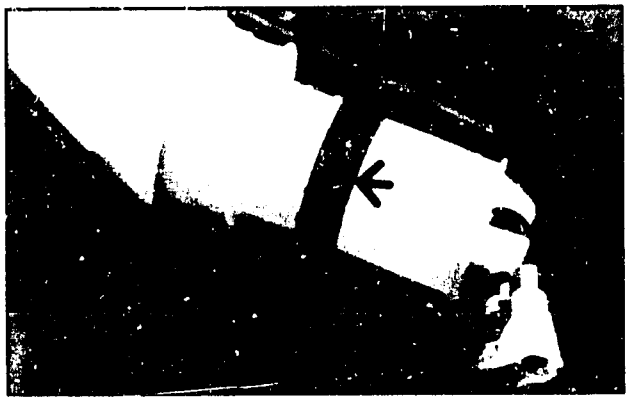
Designs including objects that can be easily cracked, or broken off by sudden impact should be avoided to the extent possible.



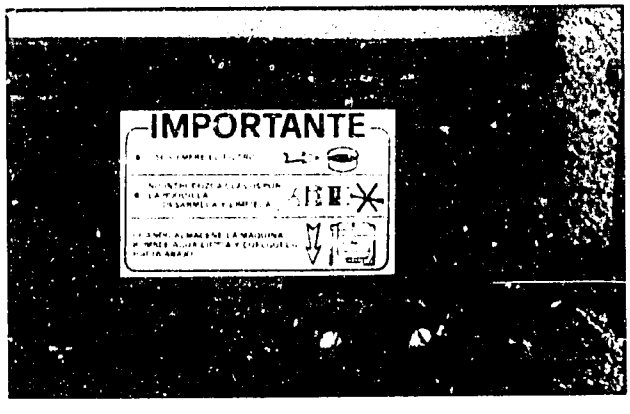


A safety test developed by IPPC that involved pushing over a full LOK-sprayer, revealed that this unit (among several) repeatedly popped off its snap-fit tank port cap ejected its basket strainer, and discharged its liquid contents over a wide area.

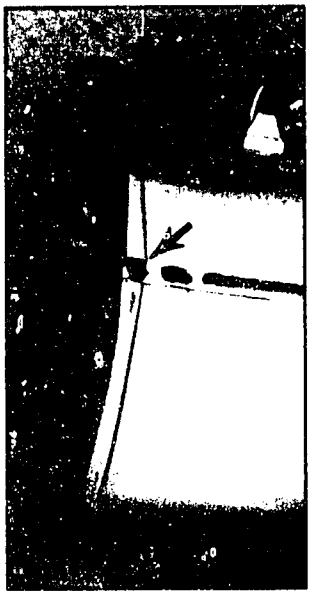
This pump cylinder collar (arrow) popped out of its seat when the full sprayer was pushed over, allowing spray solution to escape.



- *Are hose-to-tank and hose-to-lance/wand joints constructed to minimize chances of separation?*
- *Are there any snags, sharp corners or edges, rough welds, jagged spots, or protruding bolts, screws, or cotter keys that could injure the operator or damage protective gear?*
- *Are clearly understood and appropriate instructions for safe, proper use affixed to, or included with, the LOK-sprayer?*



The threaded male plastic fitting (under the cap) connecting the hose and pressure chamber broke off twice during field use. Pressurized spray solution could have seriously contaminated the operator had the sprayer been under pressure at the time.



A dangerously sharp corner at the bottom edge of the sprayer skirt was hazardous for the operator. Also note rusting welded joints.

Above (left), the sharp bottom edge on this LOK-sprayer skirt cut into the operator's hand during lifting and emptying the sprayer.

A label or panel presenting important operating instructions can be affixed to a LOK-sprayer by its manufacturer.

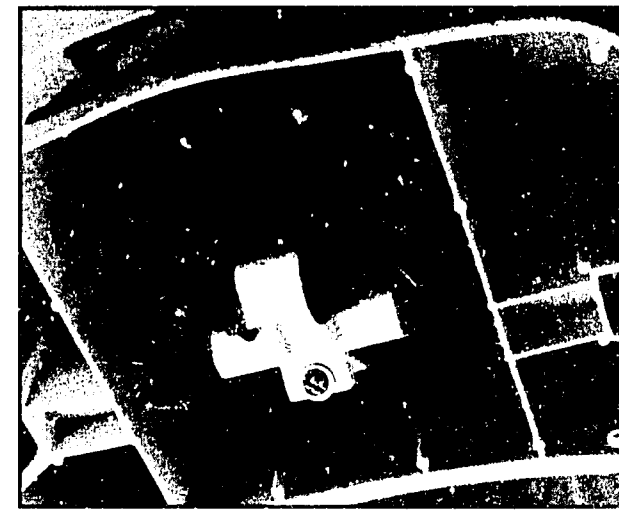
IV. Design and Construction ..... how well conceived

Some of the points in this category are purely subjective. They are included for the same purpose as preceding information: to suggest aspects of LOK-sprayers that otherwise might not be given much thought during the purchasing process.

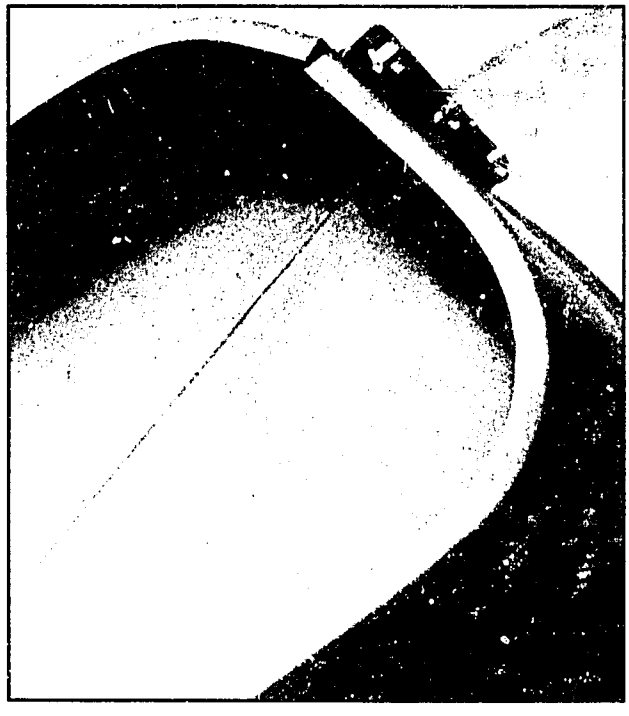
1. Overall design and construction

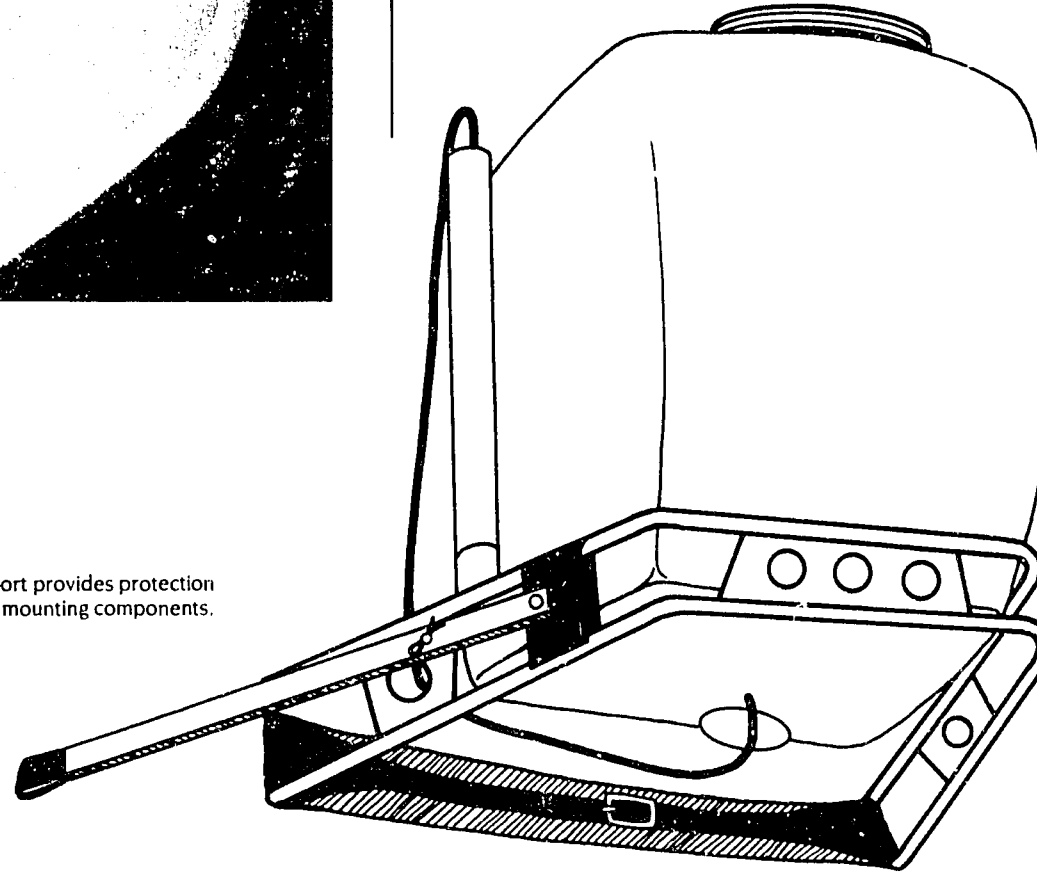
A slow, thorough inspection of a LOK-sprayer can help determine the general level of its workmanship.

- *Is the operating mechanism (pump linkage, pump housing, etc.) protected against fouling by soil or other foreign matter?*
- *Is the storage tank underside protected against being pierced by sharp objects?*



Underside view (above) shows diaphragm pump, linkage, and tank bottom protected by a skirt, though exposed to fouling by soil or other foreign matter. At left, skirt protects tank bottom against damage by sharp objects.



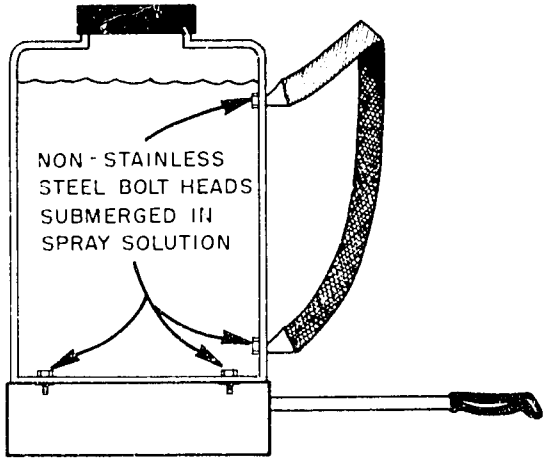


A welded, braced tubular support provides protection for the tank bottom, a base for mounting components, and a high degree of stability.

* *Does LOK-sprayer exterior minimize accumulation of foreign matter in crevices, ledges, and depressions?*

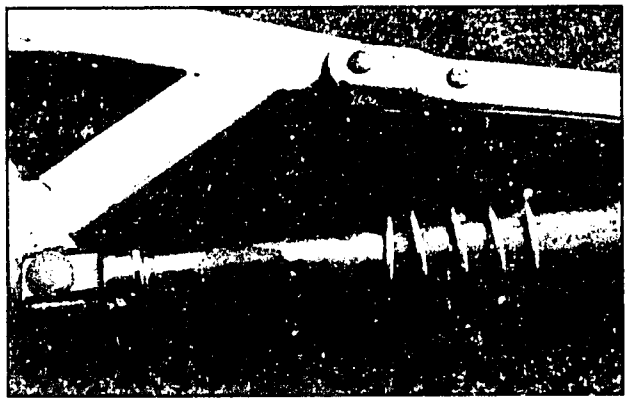
* *Is sprayer exterior easily cleaned?*

* *Are metal surfaces, other than stainless steel, monel, or brass, exposed to spray solution (bolts inside the storage tank, for instance)?*



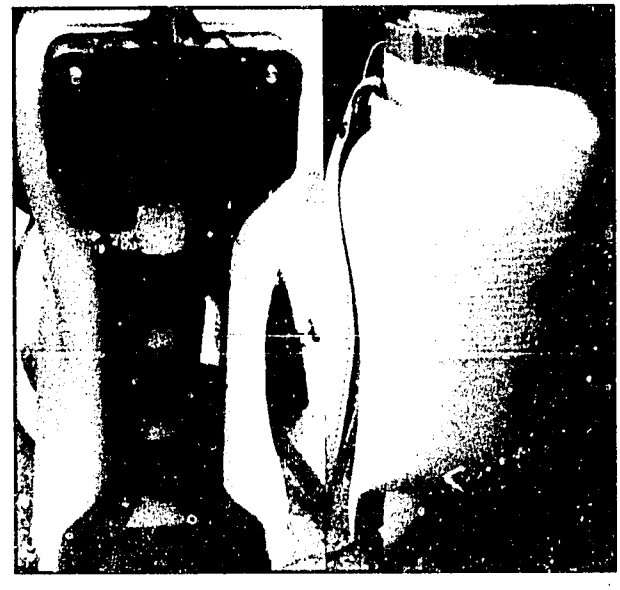
The average LOK-sprayer purchaser cannot perform material tests to determine whether internal pump parts (valves, washers, gaskets, O-rings, etc.) and hose are chemical- or oil-resistant and corrosion-proof. However, documentation supplied by the manufacturer should state this fact. And, careful inspection of pump parts should be helpful.

Increasingly, polypropylene and polyethylene are being used to form LOK-sprayer storage tanks and other elements. Aluminum can cause an adverse reaction with some spray solutions. Galvanized steel or chromed brass are less suitable than stainless steel, monel, or brass (alone) as their protective coatings often wear, scratch, or peel off. Flakes of coating may clog filters or disrupt sprayer performance.



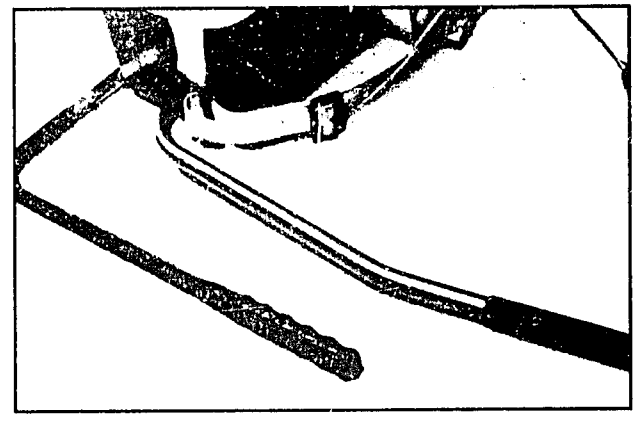
* *Is the LOK-sprayer stable, not prone to tip over during filling operations, and when full?*

As mentioned previously, a wide base and a low center of gravity are desirable.



A narrow base (left) and high center of gravity (right) detract from a sprayer's stability. Some sprayers suffer both traits.

* *Does the design/construction minimize weight?*



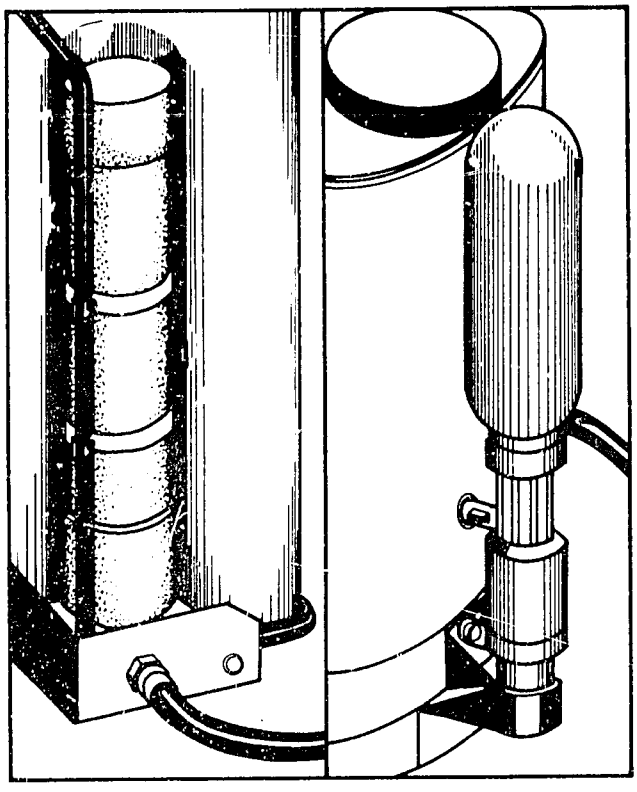
The solid bar lever arm (dark color) weighs several times more than the equally strong tubular lever arm.

Photo at left shows chrome plating that peeled off the exterior of a LOK-sprayer's pump rod.

2. Pump and pressure chamber

Positive displacement pumps—also known as plunger or piston pumps—and diaphragm pumps are used most often on LOK-sprayers. Either type is satisfactory, if well made and maintained.

- *If pump, pressure chamber, or both are mounted outside the tank, does the the sprayer frame shield or protect them against damage?*
- *Is the pump positioned and constructed so that it can be easily removed (without special tools) for servicing or repair?*



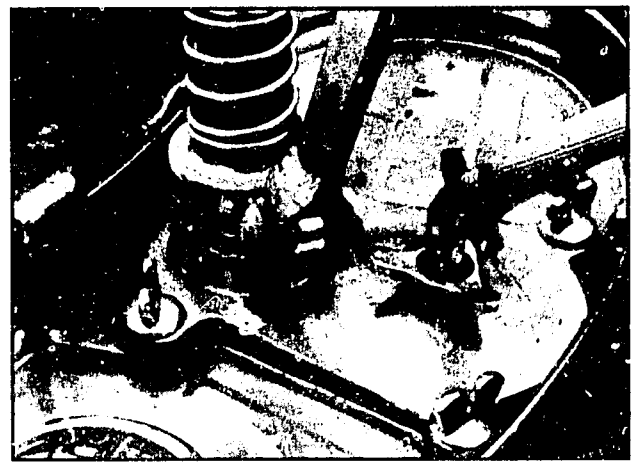
The pressure chamber (left) is protected by a tubular frame. The externally mounted pressure chamber (right) is vulnerable to damage, but convenient for servicing.

- *Is a solution agitator—either mechanical or hydraulic bypass type—provided?*

Mechanical agitators often are paddle-like pieces attached to the pump housing inside the storage tank. If their path of travel is short, their cycle rate slow, and their position well above the tank bottom, they probably will not agitate wettable powders sufficiently. To check: operate pump with tank empty and cap off to observe agitator action and position through an up-and-down cycle.

Spray output may be reduced in LOK-sprayers with hydraulic bypass agitation. The action of bypassing

Four wing nuts provide ready access to, and removal of, sprayer's pump assembly.



liquid through an agitation nozzle (or nozzles) at the bottom of the tank's interior may cause a decrease in the pressure available for spraying.

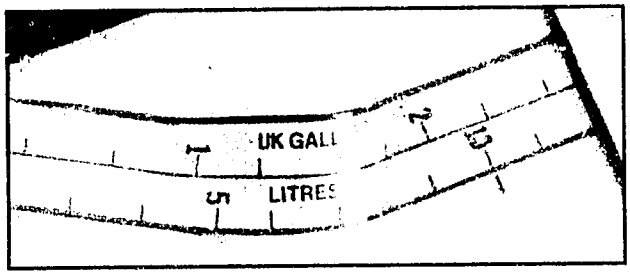
Note: if agitation is insufficient for any reason, wettable powders can be kept in suspension during spraying by a periodic, vigorous side-to-side shaking of the sprayer.

3. Contents gauge

- *Is a contents gauge provided?*
- *Can gauge be read easily from the sprayer's exterior? From inside the tank (through the tank filler port, while filling, with basket strainer temporarily removed)?*
- *Are units of measure appropriate?*

A clearly marked, permanent contents gauge specifies units of measure.

- *If an external gauge is provided, will it be permanent and not likely to wear, wash, peel, or fall off?*



A decal used as a contents gauge worked loose and eventually peeled off.

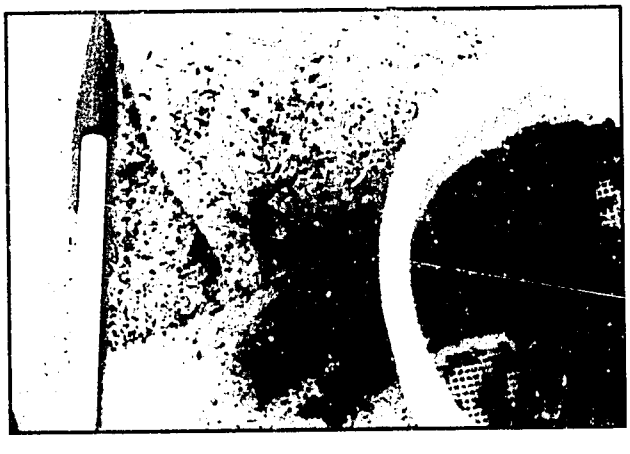
4. Strainers and filters

The pump, valves, and nozzle(s) of any spraying device need protection against entry of solid foreign matter and the chance of blockage, damage, or unnecessary wear.

LOK-sprayers usually include a **basket strainer** at the tank filler port. Also, there may be an **inlet strainer** at the entrance to the pump pressure chamber, **an in-line filter** just before the wand/lance control valve, and a **nozzle strainer** in the nozzle assembly. The more protection, the less opportunity for wear and work stoppage.

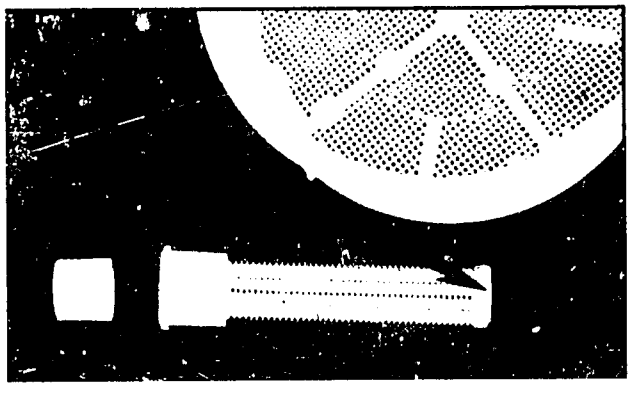
- *Is the basket strainer constructed to permit rapid filling of the tank without splash, air lock, or overflow?*
- *Does it strain adequately?*
- *Is it readily removed and replaced?*
- *Can it be cleaned easily?*

A basket strainer, made from a durable, chemically inert material, should have mesh of 0.5 mm or smaller.

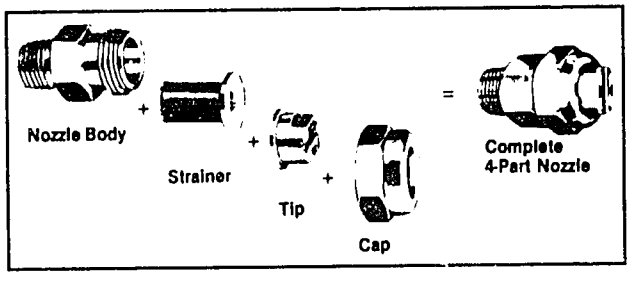


- *Is an in-line filter and/or an inlet strainer included?*
- *If so, is removal, cleaning, and replacement easily accomplished and without hazard to the operator?*
- *Do strainers seat fully and prevent fluid from bypassing?*

An in-line strainer (below) has appropriate size mesh (not larger than basket strainer mesh), one closed end (at arrow) that forces all liquid through mesh, and full contact seating that prevents liquid from bypassing mesh.



Most nozzle assemblies include a nozzle strainer. These should not be finer than 50-mesh (50 openings/lineal inch) or pesticides formulated as wettable powders will not pass. The small orifice of some (new) very low volume nozzles requires strainers with mesh too fine to work with wettable powders.



A typical nozzle assembly: while its mesh can vary, a strainer's inflow end always should be closed to obtain full filtering.

At left, while stopping very large foreign matter, this basket strainer's too coarse mesh passed material (next to pen) into the tank and pumping system, possibly causing a plugged nozzle.

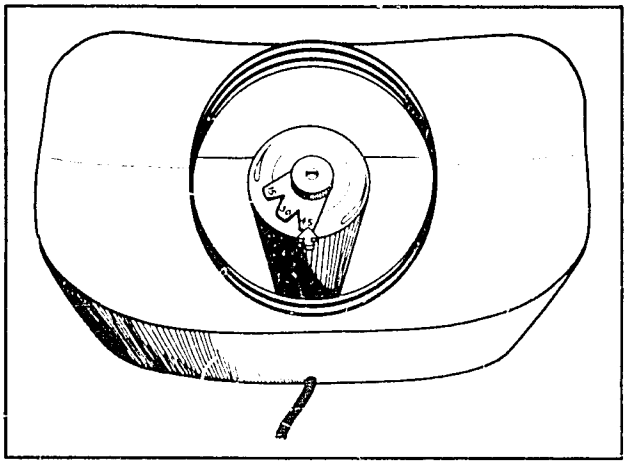
5. Pressure regulation

Some spray applications, such as research where the amount of material applied needs to be uniform, require that a steady pressure be maintained. Control of pressure is also useful in assuring that

spray droplets will not be either too small (pressure too high) or too large. Very small droplets may drift away from the target (plants or soil); very large droplets may not provide satisfactory coverage.

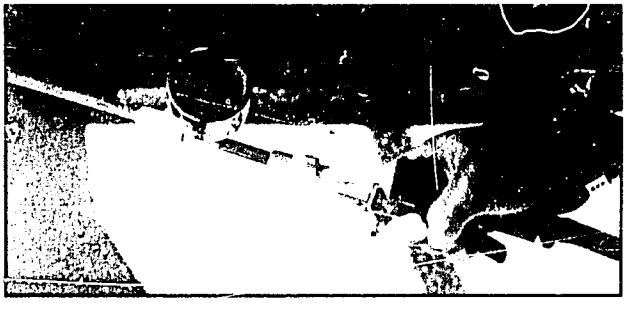
A **pressure regulator** may be fitted to a LOK-sprayer. Or, the pump on some machines may be equipped with a **pressure release valve** that allows pressure to reach, but not exceed, a preset point. Provision for changing the pump stroke also can serve a pressure-regulating function. A **pressure gauge** on the lance/wand provides the operator with useful continuous pressure readings. As they gain experience, operators become able to maintain steady pressure within a desired range.

- *Is a pressure regulator or release valve provided?*
- *If so, can it be easily and safely adjusted by the operator?*
- *What range of pressure, or pressure settings, does it allow and how well does this fit the intended spray operations?*



An adjustable pressure release valve inside the tank of several LOK-sprayers can easily be set—before filling—to operate at one of three maximum pressures as desired.

This pressure gauge, conveniently positioned for the operator, covers a usable pressure range presented in two scales.

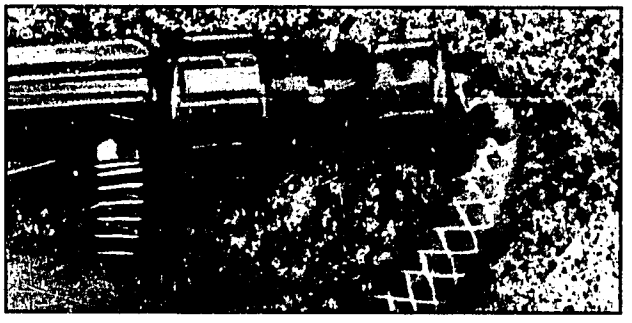


- *Is a pressure gauge included, or is there a place to install one (usually a plugged female port on, or near, the control valve)?*

A gauge should be easy to read as well as designed to cover the intended range of operating pressures. Its scale should be in either kg/cm², lb/in², or other commonly used units of measure. Lastly, it should be positioned for easy viewing by the operator.

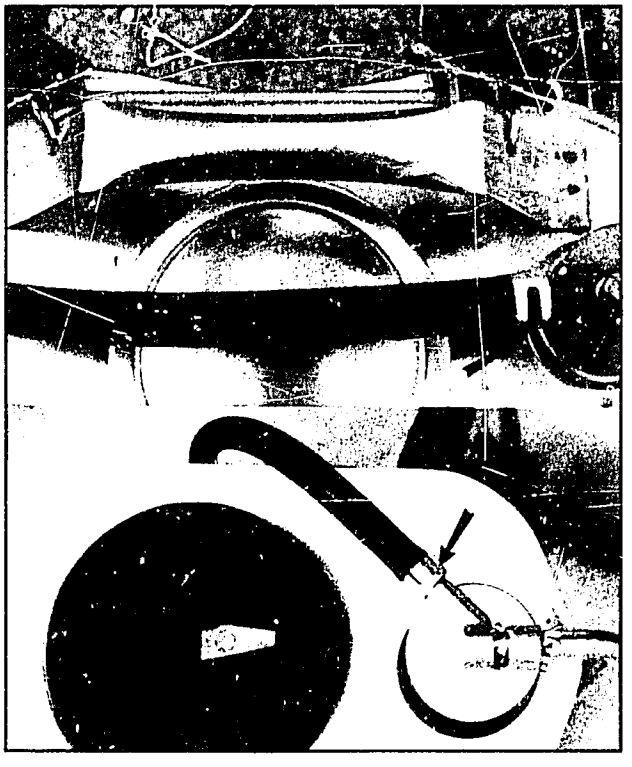
6. Hose

- *Is the hose connecting the pressure chamber to the lance/wand long enough? Durable? Reinforced?*



This hose was not strong enough to avoid crimping.

Top photo (below) shows hose inconveniently routed across tank port and cap: compare with the design directing hose away at angle. Also note difference in hose clamps used (at arrows).



- *Is it routed to avoid interfering with either the storage tank port or pump mechanism, as well as not contacting any sharp corners or edges?*

- *Has it been securely attached at both ends? Can it be easily tightened and removed without special tools?*

7. Lance/wand

Not only should the lance/wand and control valve be comfortable and easily operated (ergonomics), they should be judged on other characteristics as well.

- *Does lance/wand combine apparent durability and reasonable weight?*

- *Is a curve built into the nozzle end of the wand (for a better application angle and easier spraying)?*

A curved lance/wand positions a sprayer's nozzle for more effective application either perpendicular to the target surface, or parallel to the target surface. The curve also helps reduce operator fatigue.

- *Can lance/wand be rotated to properly align the control valve trigger with the curve?*

8. Nozzle(s)

- *What type(s) of nozzle(s) is(are) provided and is it (are they) suitable for the intended usage?*

- *Can nozzle(s) be adjusted for different spray rates and patterns?*

- *Are different or extra nozzles included?*

- *Are nozzle body and lance/wand threads compatible with international standards so that various nozzles (or nozzle bodies), manufactured by different firms, can be fitted?*

Flat fan and flood nozzles apply herbicides most effectively. Hollow cone and solid cone nozzles, while useful for insecticides and fungicides, are not as suitable for herbicides. When purchased, most LOK-sprayers are equipped with cone nozzles; thus, interchangeability with flat fan and flood nozzles is critical. Including several different types of nozzles with a LOK-sprayer increases its versatility.

- *From what material is (are) the nozzle(s) made?*

A nozzle may be a single element, or, as more commonly used in agricultural spraying, may be composed of a nozzle body or housing (the visible exterior part) containing combinations of a tip or disc, swirl plate, strainer/screen, anti-drip (ball) valve, and cap. Different, interchangeable nozzle tips or discs are designed so that: a) the amount and/or pattern of spray can be adjusted; and, b) malfunctioning tips/discs can be replaced.

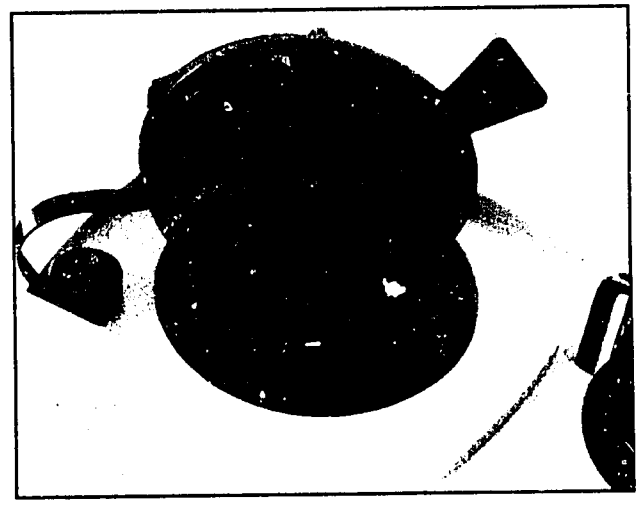
Nozzle bodies, tips, and discs are made from several materials—aluminum, brass, ceramic, nylon, or stainless steel. Each has advantages and drawbacks. Accuracy and precision are usually acceptable with any new tip or disc, but resistance to wear and corrosion varies.

Aluminum and brass tips are least expensive and, while satisfactory for spraying some solutions and emulsions, relatively unsatisfactory for extensive use with abrasive materials such as wettable powders. Some pesticides are very corrosive to aluminum. Stainless steel tips are corrosion-resistant and two to three times more resistant to wear than brass or aluminum, but cost the most initially. High quality nylon, ceramic, and stainless steel tips are all very durable.

9. Tank filler port

- *How useful and convenient is the port's position?*

- *Is port large enough to permit safe, rapid, convenient filling and emptying?*



This press fit cap, for a relatively small tank port diameter, is attached by a plastic strip judged to be annoying and difficult to use, as well as a weak point subject to fatigue and snapping off under field conditions.

* *Does its aperture allow a person to reach into the empty tank for cleaning, or to work on an internally-mounted pump?*

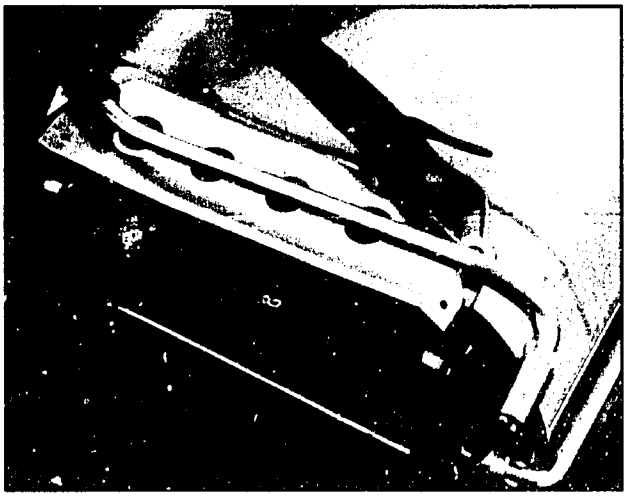
* *What happens to the port cap when it is removed? Is a security cable, chain, or clip provided to prevent loss, damage, and avoid contamination (by foreign matter) when the cap is laid aside during filling or emptying?*

10. Transporting/storing

With all their projecting parts and somewhat irregular shapes, LOK-sprayers can be a challenge to carry, handle, and store. Certain features and characteristics assist these operations.

* *Is the carrying handle, if provided, convenient and comfortable to use, even with a full LOK-sprayer?*

* *Can the pump lever arm be easily removed or folded?*



This comfortably shaped lever arm conveniently folds flat against the sprayer when not in use.

Lever arms on some LOK-sprayers can be positioned vertically for storage. A wire loop secures the lever arm on the right.

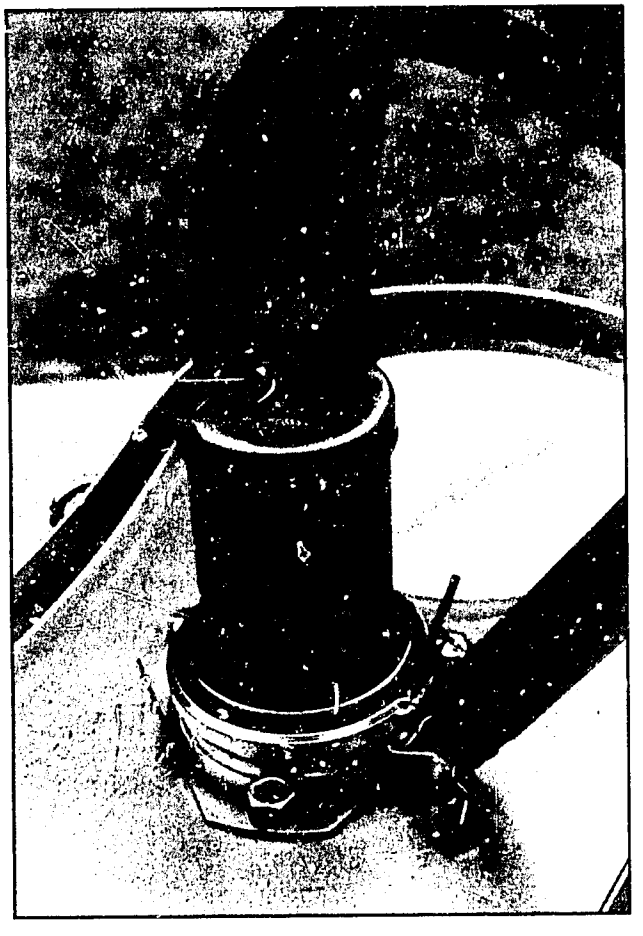
* *Are clips or rings provided on the LOK-sprayer for securing/storing the lance/wand?*

* *Does the LOK-sprayer's design permit it to be stored in an inverted postion for drying and to exclude foreign matter?*

Carrying handles (at left, top to bottom): too thin, uncomfortable for operator; next, cuts into palm of operator's hand; third, a smooth, easily grasped, comfortable handle; and, (bottom) a carrying handle cast into a sprayer's tank port cap.

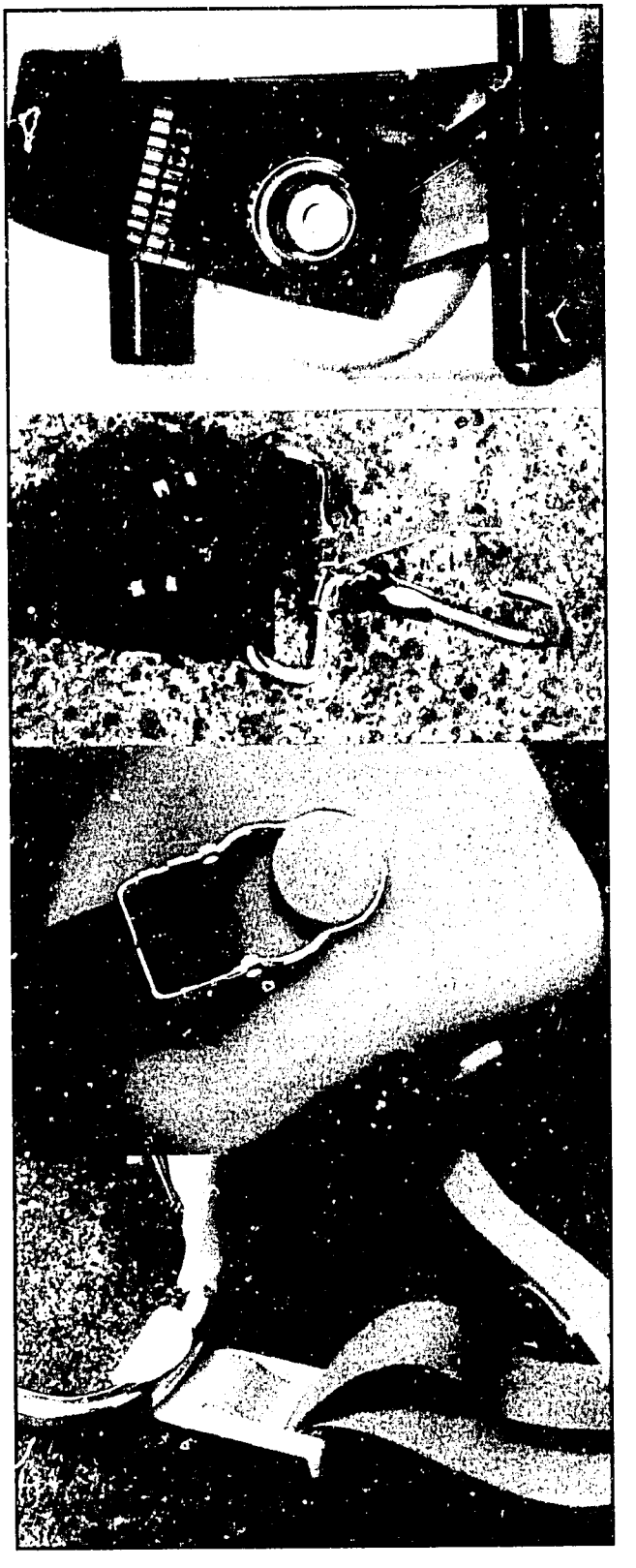
11. Miscellaneous

- *Is the LOK-sprayer a highly visible color so that it can be easily located in weeds or brush?*
- *If extra nozzles are provided, is there an arrangement or fixture to carry and store them?*
- *Is information available about the manufacturer(s), or about other testing performed on the LOK-sprayer(s) under consideration?*
- *Is satisfactory documentation provided, such as an owner's manual with visuals showing all phases of operating and maintaining the unit? Parts diagram? Addresses of service centers?*
- *Are any spare parts, tools, or lubricants included?*



A high stress, nonreinforced, major pivot point (arrow) on this over-the-shoulder LOK-sprayer was judged to be a weak element that could fatigue and soon fail. Note unsafe, exposed, sharp cotter key ends and protruding hose clamp screw.

Strap fasteners: (top to bottom) a lower strap attachment that often became unhooked; a sprung strap clip and rivets that were judged likely to fail; a well-designed knob-and-wire loop system that functioned efficiently; and, an effective plastic hook with built-in strap length adjustment feature.



V. The Perfect LOK-sprayer ..... does it exist

No. Even though the LOK-sprayer sample size (37 units) utilized for this study was reasonable, no perfect machine was encountered, nor was one anticipated. Several were judged to approach "state-of-the-art" excellence, but each incorporated at least two, if not more, undesirable features.

The bulk of the sample fell into a middle ground—machines able to accomplish most spraying tasks, but in an undistinguished manner and with a minimum of safety or comfort to the operator.

A third, much smaller group contained LOK-sprayers judged to be marginally acceptable for reasons such as:

— a lever arm that was nearly impossible to move without bruising the operator's ribs;

— a snap-fit tank cap that flew off when the full LOK-sprayer was knocked over—allowing the contents to gush out;

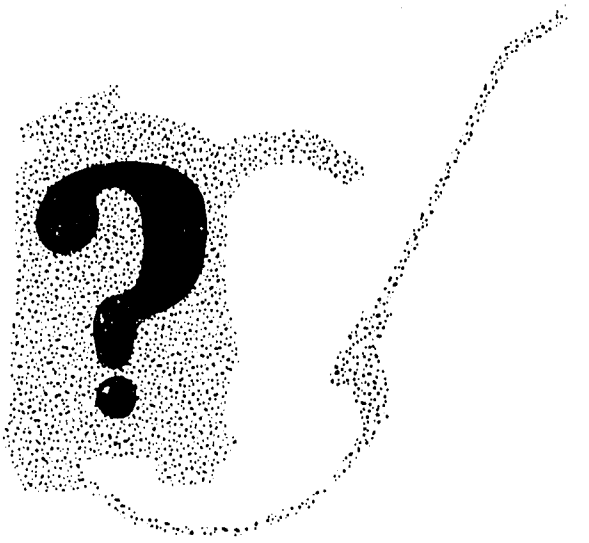
— a control valve that only could be operated using two hands, and then slowly and with difficulty;

— a sprayer with attachment of straps so low and center of gravity so high that, when full and in position, it tended to pull the operator over backwards;

— a new sprayer that, when delivered, could not be operated.

What, then, would constitute a "perfect" LOK-sprayer? In the broadest terms and considering available technology, a "perfect" LOK-sprayer should be:

- safe, presenting minimal exposure of the operator to spray solution and physical injury at all times;
- comfortable, conforming to the operator's body, distributing weight evenly, presenting controls in a reasonable location and configuration, and being designed for sustained use;
- efficient, providing adequate output with a minimum of energy expended, along with capability to operate a 4-nozzle boom; and,
- durable, offering well thought-out design and high quality parts and construction.



To repeat, if there is one general strategem that can be employed when considering a LOK-sprayer purchase, it is "try before you buy." Several basic functions can be simulated, using water, such as: filling; tipping over; hand carrying; putting on a full sprayer; pumping and spraying with it for one tankful; checking for leaks; determining amount of water left when the unit begins pumping air; and emptying the tank.

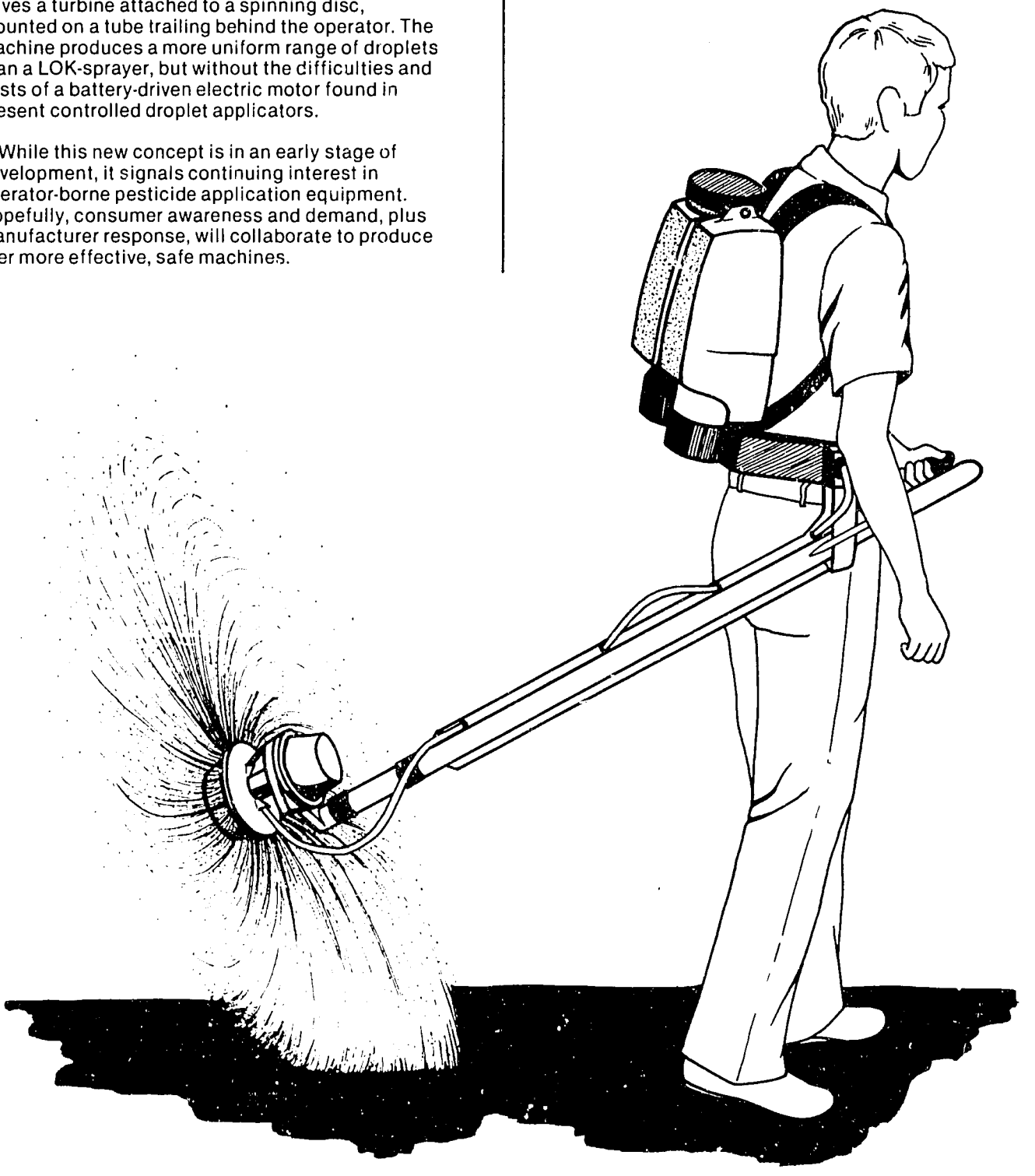
If the intent is to purchase numerous LOK-sprayers— for instance, two for each of 10 research stations—an initial purchase of one each of two or three different brands might be useful. These could serve as "guinea pig" units to be used, observed, and evaluated under actual field conditions before concluding the main purchase.

In addition to general technical considerations, quite obviously initial cost, ease of repair, and availability of service and spare parts need to be evaluated.

Postscript

Even since the IPPC LOK-sprayer program reached a resting point, a new genre of applicator appeared on the horizon combining the virtues of a LOK-sprayer with the advantages of a spinning disc, controlled droplet applicator. Instead of pumping liquid, the operator of this new device uses a lever to activate an air pump. The compressed air generated drives a turbine attached to a spinning disc, mounted on a tube trailing behind the operator. The machine produces a more uniform range of droplets than a LOK-sprayer, but without the difficulties and costs of a battery-driven electric motor found in present controlled droplet applicators.

While this new concept is in an early stage of development, it signals continuing interest in operator-borne pesticide application equipment. Hopefully, consumer awareness and demand, plus manufacturer response, will collaborate to produce ever more effective, safe machines.



Suggested Related Reading

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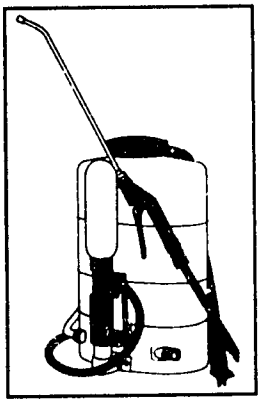
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