

# **Model 9306A Six-Jet Atomizer**

## **Instruction Manual**

*P/N 1930099, Revision B  
February 2003*



# Manual History

The following is a manual history of the Model 9306A Six-Jet Atomizer Instruction Manual (part number 1930099)

<b>Revision</b>	<b>Date</b>
New Version	November 1998
A	August 2000
B	February 2003

This new version replaces the Model 9306 Six-Jet Atomizer instruction manual (part number 1990143) and TSI's area code was changed from 612 to 651.

In revision A, TSI's Limitation of Warranty and Liability was updated.

In revision B, TSI phone numbers and address were updated.

**Part Number**  
**Copyright**  
**Address**  
**Fax No.**  
**E-mail Address**  
**Limitation of Warranty  
and Liability**  
(effective July 2000)

1930099 / Revision B / February 2003

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# About This Manual

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## Purpose

This manual describes and gives installation information for the Model 9306A Six-Jet Atomizer.

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## Getting Help

To report damaged or missing parts, for service information or technical or application questions, contact:

TSI Incorporated (Particle Instruments)  
500 Cardigan Road  
Shoreview, MN 55126 USA  
Fax: (651) 490-3824  
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# Model 9306A Six-Jet Atomizer

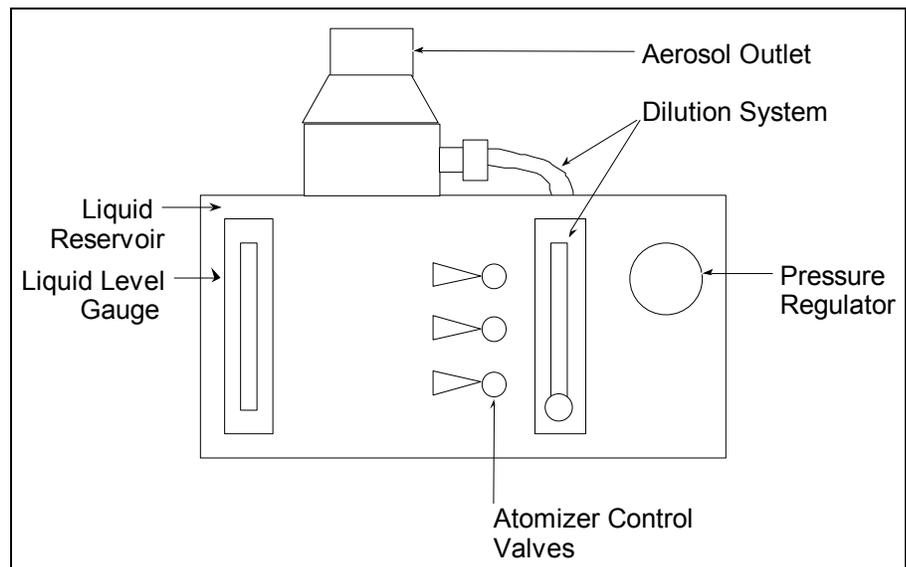
The Model 9306A incorporates several special features which makes it a convenient and flexible instrument. The system has a built-in pressure regulator and pressure gauge. It also has a self-contained dilution system and can select one to six particle-generating atomizer jets. The result is a broad range of control over both the particle number concentration and over the total particle output.

The atomizer can generate particles from virtually any liquid. It can even produce solid particles from solutions or from suspensions, for example, particles from uniform polystyrene latex (PSL) spheres.

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## Subassemblies

This section describes the atomizer's four subassemblies and their functions: the pressure regulator, atomizers, dilution system, and aerosol outlet. Figure 1 identifies these subassemblies on the atomizer.



**Figure 1**  
Model 9306A Six-Jet Atomizer, Outline Drawing

## **Pressure Regulator**

A regulator and pressure gauge are mounted on the atomizer. The regulator controls the input pressure which is displayed on the gauge. The precise relationship between input pressure and aerosol output is discussed later under “Operating Characteristics.”

## **Atomizers**

All six atomizers may be used at one time. Figure 2 shows one of the six individual particle-generating atomizers within the liquid reservoir.

The operating principle of the atomizer is simple. As shown in Figure 2, pressurized air forms a high-velocity jet through a 0.015-inch-diameter orifice. The pressure drop from this jet draws liquid up through a narrow tube. The liquid is then broken up into droplets by a high-velocity air jet. The resultant larger droplets impinge on the spherical impactor, while the smaller droplets make no contact and form an aerosol that exits through a specific outlet.

## **Dilution System**

The atomizer incorporates an aerosol dilution system. Dilution air is used to vary the output concentration and to help dry the solid particles that are generated from a solution.

A rotometer is mounted next to the regulator which gives the flowrate of the dilution air.\* A valve at the base of the rotometer controls the flowrate.

## **Aerosol Outlet**

Figure 2 shows the outlet assembly in cross-section and outlines the basic operation. The assembly meets the high aerosol output that is demanded when all six atomizer jets are used and/or when high dilution-air settings are used.

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\*The dilution air that is available to the atomizer diminishes when the input pressure falls below 20 psig.

The relatively large aerosol outlet was selected to maintain low aerosol velocities.

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## Operating the Atomizer

### Adding Atomizer Liquid

Remove the red plastic filler cap on the cover of the reservoir and pour in the liquid to be atomized.

Observe the liquid level shown in the glass gauge on the front panel. Fill the reservoir no more than half to ensure that the atomizing jets are not submerged.

### Connecting the Compressed Air

Be sure to close both the regulator valve and the dilution air valve before connecting the compressed air. To close the regulator, turn its knob counterclockwise until at least three-fourths of an inch of shaft is exposed. To close the dilution air valve, turn it fully clockwise.



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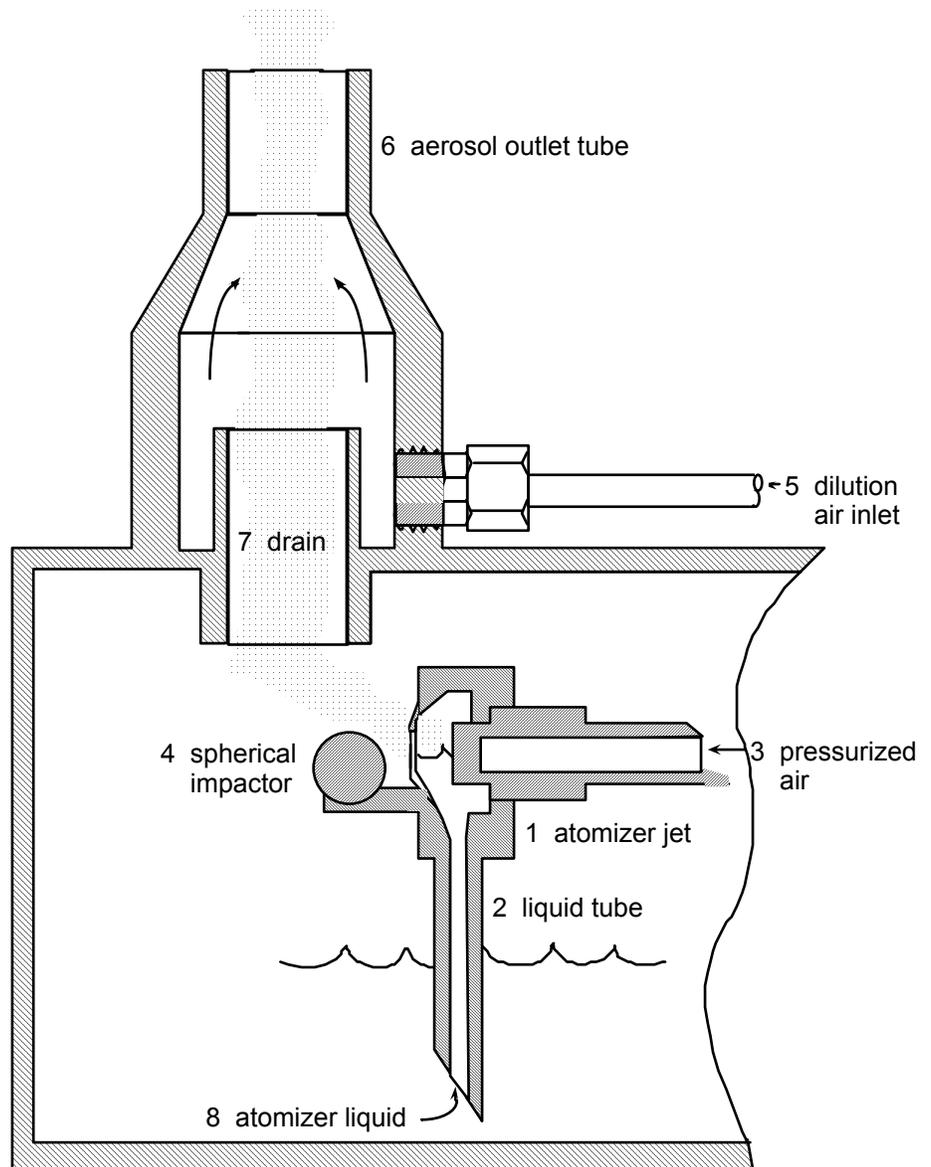
#### **C a u t i o n**

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The compressed air source must not exceed the regulator's maximum pressure specification of 250 psig.

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Now connect a source of clean compressed air to the atomizer at the inlet fitting on the pressure regulator.



**Figure 2**  
 Schematic Drawing of the Aerosol Outlet and Atomizer Assemblies; the Numbers Give the Order for Disassembling the Instrument

## Connecting the Aerosol Outlet

Connect the atomizer to the flow system that is to be seeded using 1-inch ID flexible tubing (Tygon<sup>®</sup>, for example). Slip the tubing over the aerosol outlet. Under atmospheric conditions, no hose clamp is necessary.

## Setting the Regulator Pressure

The atomizer works well under input pressures between 20 and 50 pounds per square inch. At atmospheric conditions, an input pressure of 25 pounds per square inch is typical.

## Operating the Jets

Open the jet or jets needed. Three *on/off* valves control their operation. The label beneath each valve indicates the number of jets that each valve controls. Thus, the valve labeled 1 JET controls a single jet; the valve labeled 2 JETS controls two additional jets, while the valve labeled 3 JETS controls three additional jets. From one to six jets may be operated by opening the appropriate valve(s). In other words, if the valves labeled 1 JET and 3 JETS are open, a total of four jets would be in operation.

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# Operating Characteristics

## Aerosol Flowrate

Table 1 shows typical flowrates at several input pressures. This data is valid for a single atomizer jet at atmospheric pressure. The total aerosol flowrate is directly proportional to the number of jets used.

If the atomizer is used to seed a flow under pressure, the aerosol output will naturally differ from the value given in Table 1.

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<sup>®</sup>Tygon is a registered trademark of Norton Performance Plastics Corporation.

**Table 1**  
**Aerosol Flowrate Per Jet**

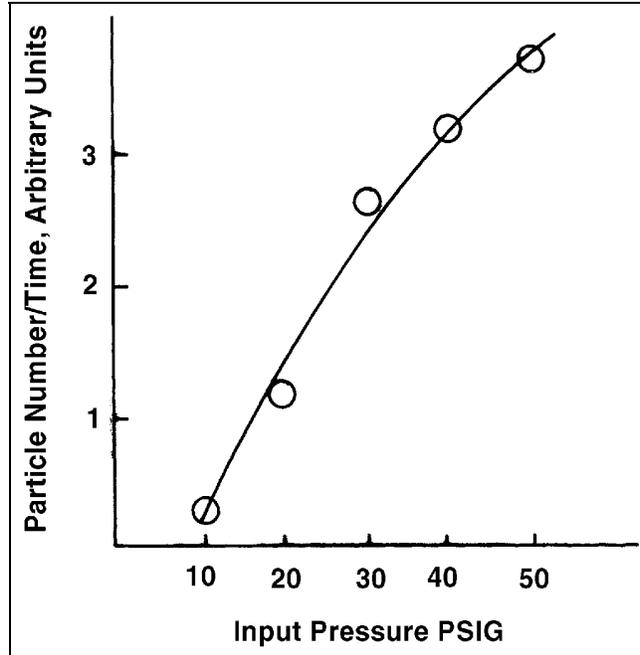
<b>Input Pressure</b>	<b>Aerosol Output*</b>
<b>psi</b>	<b>kPa L/min</b>
5	34.5 2.4
10	68.9 3.7
15	103.0 4.7
20	138.0 5.7
25	172.0 6.6
35	241.0 8.3
45	310.0 10.2
55	379.0 12.0

\*Outlet open to the atmosphere.

## Particle Output

The total particle output depends on the input pressure and the number of jets operated. At fixed input pressures, the particle output is directly proportional to the number of jets that are open.

When the input pressure changes, the particle output changes as graphed in Figure 3.



**Figure 3**  
Relationship Between Number of Atomizer Particles Generated and Input Pressures

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## Maintenance

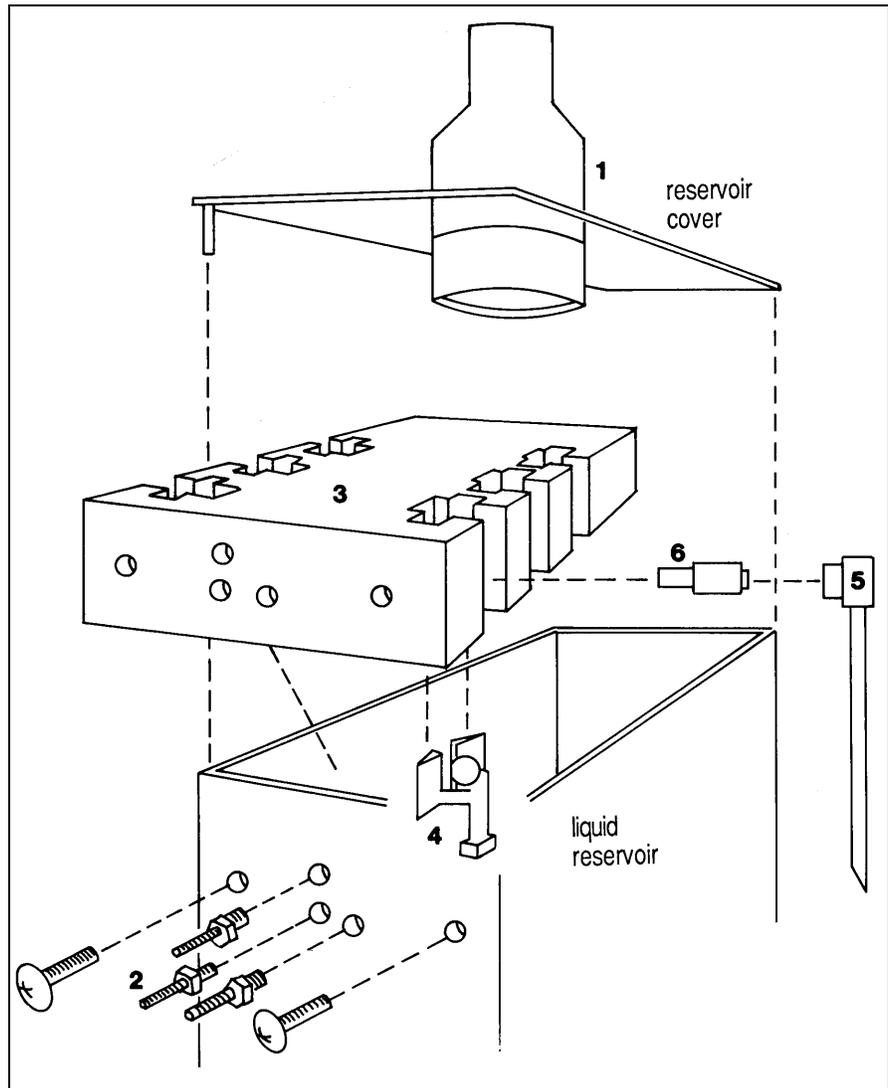
Routine maintenance on the atomizer is typically unnecessary. There are times, however, when you should clean the generator, typically before using a different liquid.

### Cleaning

Cleaning should be limited to those components that come in contact with the atomizer liquid, for example, the liquid reservoir, the atomizers, and the outlet assembly. Figure 4 shows an exploded view of these components; the numbers give the order in which the parts should be disassembled. You can clean the atomizer better if you separate its components. Often it is unnecessary to disassemble the generator before cleaning it. Simply empty the old

liquid from the reservoir and rinse it several times with a suitable solvent.\*

After draining the excess solvent, allow the reservoir to dry; then add the new liquid. Note, however, that this simplified cleaning method will probably cause mild contamination of the new liquid.



**Figure 4**  
How to Disassemble the Atomizer for Cleaning

\*A suitable solvent readily mixes with the atomizer liquid and evaporates quickly. Isopropanol and water are common.

## Clogged Jets

Occasionally the atomizer jets may become clogged.\*\* Typically, the atomizer liquid is not clean. You must remove the jets in order to clean them (Figure 4).

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# Seed Materials

## Liquid Particles

The atomizer is used most often for generating liquid seed particles because liquid particles are spherical, inexpensive, and can be generated by the atomizer at high concentrations. Typical materials would include Dioctyl Phthalate (DOP), Polyethylene Glycol 400, Oleic Acid, Olive Oil, and Propylene Glycol.



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### C a u t i o n

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Proper ventilation is needed to prevent inhalation exposure to the generated aerosols. The long-term effects of ingesting or inhaling many compounds, including some described here, are still unknown.

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## Solid Particles

### NaCl or Sugar

NaCl or sugar particles may be generated in the atomizer by atomizing a solution of these solids. Once completely dried, the final size of the particles depends on the concentration of the solution used; thus, a lower solids concentration yields smaller particles. Since the solubility of sugar is higher than NaCl, sugar is preferred when particles larger than 1 micrometer are desired.

### Monodisperse Latex Particles

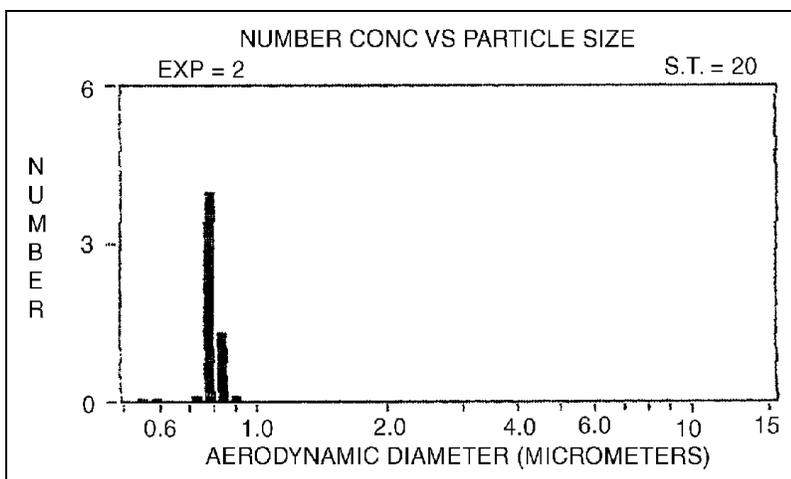
A monodisperse aerosol can be generated by dispersing uniform PSL particles using the atomizer. The resultant monodisperse PSL aerosols are very useful for system evaluation and calibration.

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\*\*When cleaning an atomizer jet, be careful not to damage its orifice.

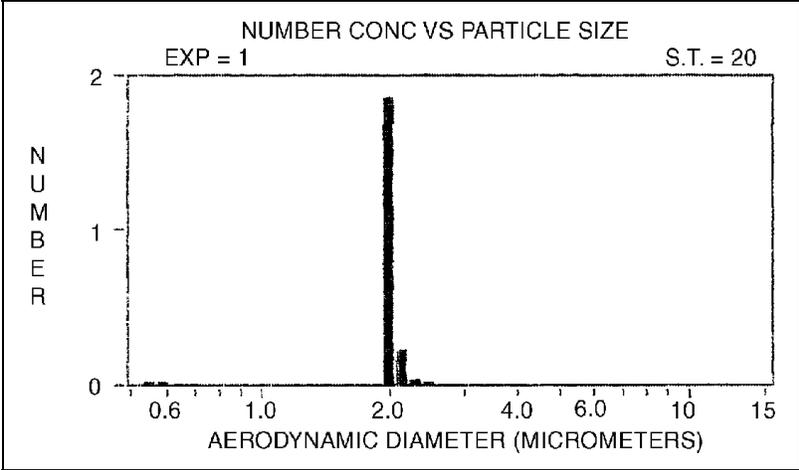
To generate PSL particles, make a very dilute solution (about two to three drops in one liter of distilled water) and atomize the solution with the atomizer as described previously under “Operation.”

1. It is important that the solution be sufficiently diluted so that the probability of a liquid droplet containing more than a single PSL particle is low. This becomes more important when the aerosol is intended for system calibration. For seeding, a more concentrated solution may be used (10 drops per liter).



**Figure 5**  
Particle Size Distribution of a 0.797-micrometer Monodisperse PSL Aerosol

2. When a very dilute solution is atomized, many water droplets contain no PSL particles. When these empty water droplets dry out, they are reduced to small residual particles. Thus, the particles generated by this technique always contain both the particles of desired size and smaller residue particles. The presence of residue particles is discussed in Whitby and Liu [4].
3. An aerosol of original particle size is obtained only after the liquid droplets are completely dry. Mixing the aerosol with a sufficient volume of warm, dry air is perhaps the best way of drying the particles. A simple system for drying the droplets is described in Agarwal and Fingerson [3].



**Figure 6**  
Particle Size Distribution of a 2.02-micrometer Monodisperse PSL Aerosol

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# Specifications

The following specifications—which are subject to change—list the features of the Model 9306A Six-Jet Atomizer.

**Table 2**  
Specifications for the Model 9306A Six-Jet Atomizer

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<b>Number mean droplet diameter ..</b>	0.35 $\mu\text{m}$ for water, 0.3 $\mu\text{m}$ for DOP
<b>Geometric standard deviation .....</b>	<2
<b>Particle concentration .....</b>	$>10^6$ particles/ $\text{cm}^3$
<b>Particle material .....</b>	PSL, DOP, DEHS, oils, and other aqueous or alcohol solutions or suspensions
<b>Maximum PSL particle size .....</b>	4 $\mu\text{m}$
<b>Number of jets .....</b>	6 (selectable)
<b>Flowrate per jet .....</b>	6.5 L/min at 170 kPa (25 psig), 12 L/min at 380 kPa (55 psig)
<b>Normal operating pressure .....</b>	170 kPa (25 psig)
<b>Maximum inlet pressure .....</b>	550 kPa (80 psig)
<b>Maximum outlet pressure .....</b>	102 kPa (15 psig)
<b>Materials of construction .....</b>	Anodized aluminum, plastic
<b>Outlet port dimensions .....</b>	2.5 cm (1.0 in.)
<b>Instrument dimensions (LWH) .....</b>	32 cm $\times$ 12.5 cm $\times$ 26 cm (12.6 in. $\times$ 4.9 in. $\times$ 10.2 in.)
<b>Weight .....</b>	2.7 kg (1.2 lb)

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*TSI Quarterly, Vol. III, No. 3* (1981) (Appendix A)
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