NEW TECHNOLOGY IN ELECTROSTATIC SPRAYING SYSTEMS

Mark Evans,
United Air Specialists, Inc. Cincinnati, Ohio

The information contained in this paper has been cleared by United Air Specialists, Inc.

A. INTRODUCTION

Electrostatic spraying systems are not new to the building products industry; however, some terms or phrases used in our presentation may be unfamiliar. To eliminate any uncertainty, we would like to clarify some of these:

* Firing - propelling/spraying action caused by electrically charging oil.
* Gradient force - concentration of electrical forces at the point of firing.
* Inductor bar - a mechanical/electrical device used to assist in firing, as well as direct, or steer, the spray.
* Ligaments - fine streams of oil emitted from the nozzle edge.
* Meniscus - accumulation of oil on the nozzle edge.
* Serrations - triangular saw toothed type of projections on the nozzle edge used to create uniform flow and droplet size.
* Shim - stainless steel material encased in the nozzle used to both charge and control fluid flow.
* Slot - the orifice which oil passes through to form a meniscus.

The new technology we are presenting today was awarded a patent in June, 1988, with two additional patents pending at this time. Prior to the award, several years of experimentation and research effort formed the knowledge base of the invention. The new technology is focused on a device whose function is to simultaneously charge and spray fluids. While the creation of this device was developed for a wide variety of chemical fluids, substantial development was undertaken to perfect its ability to electrostatically spray the types of fluids used in the steel and food industries. The objective of the design effort for each market was to provide a nozzle that:

1. would deliver precise and controllable droplet sizes consistently.

2. prevents non-uniform wandering ligaments and subsequent streaks on the product.

3. had no moving parts or clogging problems.

4. could handle a range of fluid viscosities.

5. would require no mechanical pressure to virtually eliminate overspray.

6. could be designed to match spray width to web width.

7. used low electrical power.

The design objective was met for the steel industry in May, 1988, when a series of line trial runs were conducted on a 48" slitter line at a major steel company in northern Indiana. The results of these tests demonstrated conclusively that this new design technology could be utilized in the steel industry for quality oiling. This fact was established by the experienced observation and validation of industry experts.

The name for the new nozzle technology for electrostatic application of fluids is TotalStat®. As its name implies, the device is totally electrostatic - it uses no pressure to generate a uniform and consistent spray.

B. MATERIAL DESIGN

NOZZLE DESIGN:

The TotalStat nozzle is electrohydrodynamic in type which differs from hydraulic, air atomizing and rotary atomizing type nozzles. The difference resides in that only electrostatic energy is used to produce dropletization of the fluid to be sprayed.

The nozzle is comprised of two pieces of non-conductive material, typically an acetal plastic, that clamp firmly around the metallic shim-electrode. The fluid is introduced to an internal lateral cavity. High voltage DC is applied to the shim by means of an electrical connection. Typical hydraulic pressures internal to the nozzle are less than 5 psi, and are often as little as 0.1 psi. No atomization results from this pressure by itself... in fact, merely a slack flow of fluid from the tips would occur in a non-charged nozzle. High voltage DC ranging from 30 to 80 kilovolts (depending on the particular system's design) is applied to the electrode transferring a strong charge to the fluid internal to the nozzle cavity, and to that resting at the meniscus.

The charging of fluid causes the fluid to assume the same polarity within the nozzle. This in turn causes a strong negative charge gradient to be formed on the nozzle tips. Therefore, the fluid is ejected in a controllable and predictable manner off the serration tips. The ejection is first in the form of ligaments, and subsequently, highly charged uniform droplets.

Uniformity feeding each nozzle with the same fluid flow results in the creation of equivalent ligaments, and therefore, uniform droplets. A strong image charge steering force is induced as the droplet approaches a three inch proximity to the substrate. If the droplet size is in the 300 micron range or smaller, it will steer towards the substrate, greatly exceeding gravity and aerodynamic influences, and forcibly impact it, without bounce. If the droplets are in the 100 micron and under range, there may even be a steering force near the point of impact whereby the droplet will avoid a like-charged droplet already on that surface. It will be deflected by that droplet and seek out the adjacent uncoated area of the substrate to land without bounce.

TotalStat can atomize fluids with a wide range of viscosities, resistivities and surface tensions. Viscosities can range from 1 to 20,000 CPS, resistivites from 10 exp 7 to 10 exp 10 OHM-CM, and surface tensions from 20-80 dyne-cm's. Droplet size range can be as small as 0.5 micron to as large as 2000 micron. Throughout the range of flow, droplet size uniformities are within 10 percent of the mean, for a given flow. Droplet size does increase as flow increases. Therefore, additional nozzles can be used if the droplet size is the most important variable.

The reason that the TotalStat nozzle produces very uniform coatings, resides in the charging efficiency of the nozzle. Rayleights limit states that droplets will divide until the charge to mass ratio is equal for that particular fluids surface tension. TotalStat charges fluid at 100% charge to mass ratio thereby inducing a uniform droplet size, causing the droplets to be equally attracted to the substrates surface, without overspray.

SYSTEM DESIGN:

After the development of the nozzle, a dedicated group of engineers investigated various types of hardware designs, equipment packages and electronic components to integrate the nozzle into a complete system. The objective of this effort was to produce a fully automatic state-of-the-art electrostatic spraying system for a multitude of applications.

Utilizing inherent design features of the nozzle which included the ability to match fluid spray width to web width, the lack of fluid pressure and the low electrical power to propel oils, our engineers developed the TotalStat system shown in this slide.

TotalStat Systems regardless of the application typically require a fluid reservoir, pumping system, nozzle assembly, and electronic controls. Each system is custom engineered for each applications specific requirements.

D. RESULTS AND DISCUSSION

SYSTEM DESIGN - ANTI-SAPSTAIN:

The preliminary design of the TotalStat System to apply the Nytek 10BL indicates that four rows of nozzles on the top and four rows of nozzles on the bottom are required to apply 14 $\mu g/cm^2$ of material at mill speeds.

Control of the deposition will be achieved through the use of a programmable logic controller (PLC). The operator will enter (via thumbwheel) the deposition required (in $\mu g/cm^2$) and the size of board to be sprayed. A table will be supplied to correlate board size with thumbwheel setting. The PLC will then determine the correct width of nozzle zone to spray and the correct pump speed to achieve the desired deposition.

The pumping system consists of Zenith positive displacement (gear type) pumps that are accurate to ± 1% of setpoint. The Zenith pumps are driven by a variable speed DC motor and drive.

Nozzle header configuration is as depicted on UAS Drawing Number Nytek 10BL. It is important that the top and bottom headers are offset to prevent like polarity fields from interfering with the spray pattern. Extremely high transfer efficiencies are obtainable while using ultra-low volume depositions.

The reservoir system will be determined by the method of day storage supply of the Nytek 10BL to the lumber industry.

The overall objective in utilizing the TotalStat Technology to apply Nytek 10BL onto lumber includes the following:

1. Uniformity of application across and along the board to achieve superior efficacy.

2. Ultra-low deposition of anti-sapstain chemistry to achieve legal limits of leachate allowable.

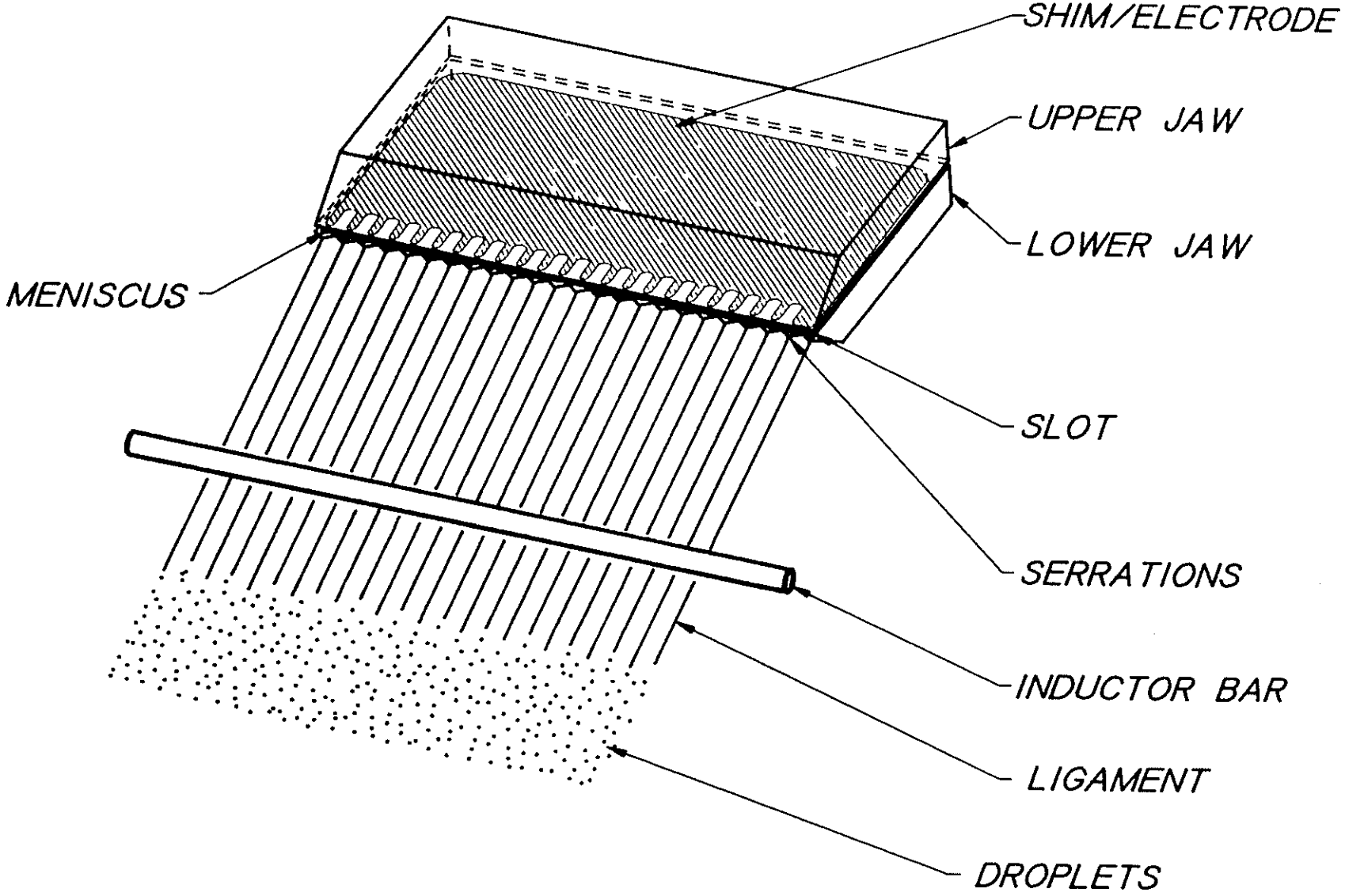
3. Simple operator controls.

4. Clog free nozzles.

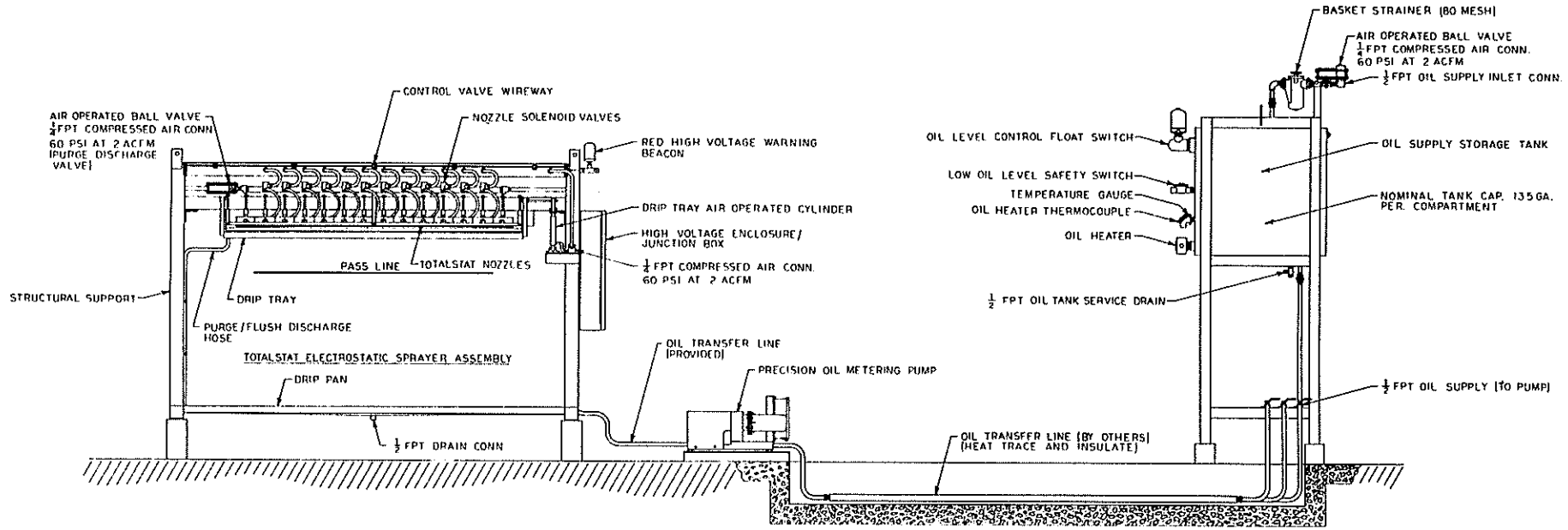
E. CONCLUSIONS

The TotalStat electrostatic technology presented today has been developed for several specific applications. Having met the design objective in the steel industry, twenty-five (25) systems have been purchased. Eight (8) systems have been purchased in the food industry.

The flexibility of use in various applications positions TotalStat as a technology that can be utilized with little development for new applications. Ease of integration of the technology into existing processing makes TotalStat a logical choice for new applications.


SHIM/ELECTRODE
UPPER JAW
LOWER JAW
MENISCUS
SLOT
SERRATIONS
INDUCTOR BAR
LIGAMENT
DROPLETS

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



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TITLE: TOTALSTAT SYSTEM ELEVATION

SIZE	DWG. NO.	REV.
D	44-1027	

SCALE | SHEET

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CINCINNATI, OHIO

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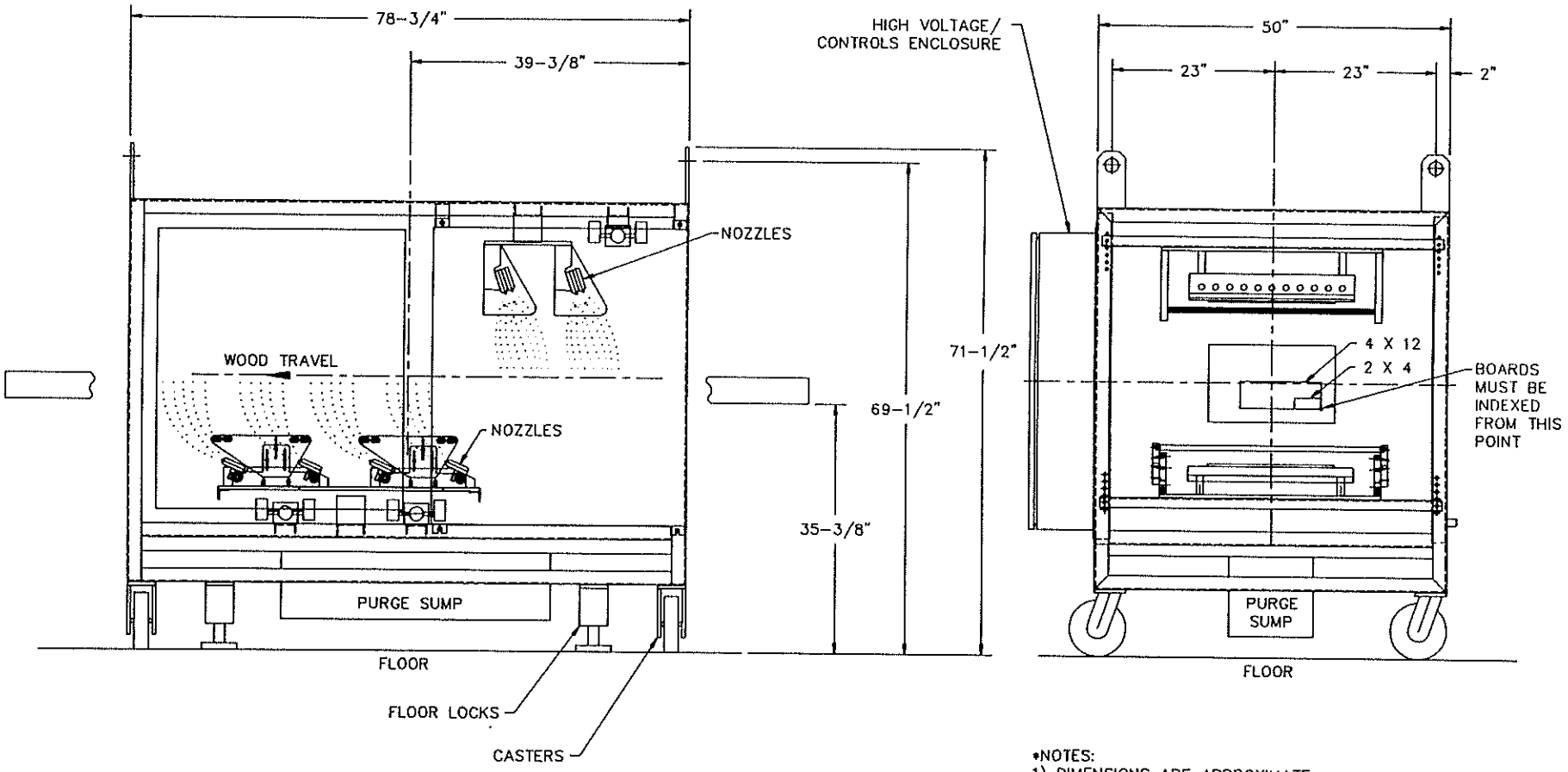

*NOTES:
1) DIMENSIONS ARE APPROXIMATE
2) PUMPING SYSTEMS AND PLC CONTROLS ARE SEPERATE ASSEMBLIES

175

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCE: FRAC. ± DECI. ± ANGLES ±	SIGNATURES	MO-DA-YR
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TOTALSTAT OILER CONFIGURATION

SIZE		REV.
B	NYTEK10BL	
SCALE 1=15	SHEET 1	

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