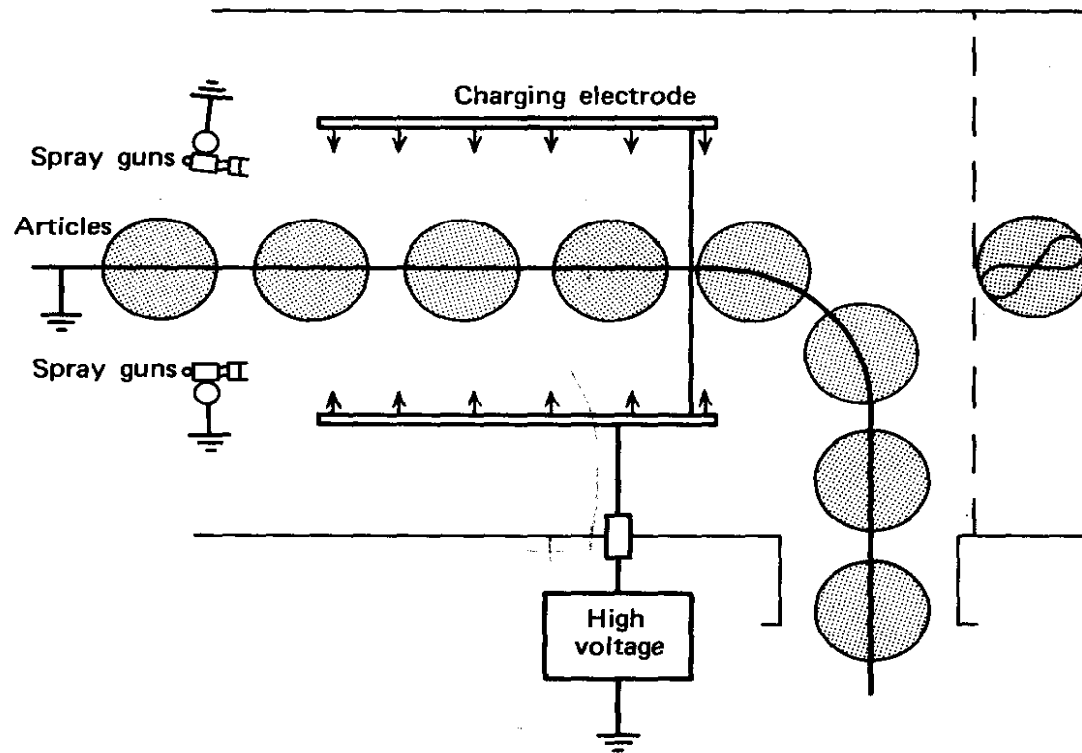


ELECTROSTATIC COATING

- Electrically charged bodies – attracted to or repelled from each other.
- If free to respond – this attraction or repulsion was made apparent by the movement of the bodies.
- Air cleaning by Electrostatic as early as 1800.
- Coating – broad term – all processes – wet or dry material applied over a surface to produce on a layer for protection coat.
- Electrostatic- Direct or Indirect- deposition of material
- Every product or article manufactured and sold is coated at least once during its production
- The paper sheets are coated – to produce the surface quality needed for good print production
- The brass hardware – protect original luster from chemical corrosion.
- Automobiles – at least 3 successive coatings- protect base metal-corrosion. – final beautiful appearance
- Materials employed for coating add to cost.
- Preferable to have min. Loss.
- Process of coating should be simple and automatic preferably
- Sometimes – special condition, state or orientation – towards intended function.
- In the most simple form-
- Article(to be coated) supported : can be approached without any obstruction.
- Coating material distributed in the form of finely divided particle over the surface (to be coated)
- Suspended particles are charged (-ve) and surface (+ve)
- Particles are attracted to the surface more towards and accumulate on the surface forming a coating.
- VARIOUS METHODS – differ- Formation of particles means of charging particle and distribution and particle collection

LIQUID ELECTROSTATIC COATING

- **Automatic No. 1 Processes**
- **1930s** – Industrial coatings became prominent
- **Liquid** plastic solutions applied wet – cured to develop solid plastic surface film.
- Normally applied by an ordinary air spray gun.
- Fast but inefficient.
- Depending on the shape 50 and 80% of the material was lost.
- Incentive – existed to devise a method that would save this oversprayed material and eliminate the labor and expense associated with its collection.
- Ransburg and green – 1940s – brought ES
- Sprayed particles if charged would be attracted to article – without getting blown past and wasted.
- Articles to be coated are supported on a conveyor
- Carried into a coating enclosure or booth
- Inside – charge- depositions electrode- with a series of sharp pts / fine wires are located . It is held α 100 kV with respect to the articles.
- It is spaced approximately a foot away from the articles to avoid the occurrence of disruptive discharges



Schematic layout of a No. 1 automatic electrostatic spray-coating installation, parallel spray introduction.

- At the entrance end of the booth, there is an exhaust system which creates a general airflow from the open exit end of the booth toward the exhaust.
- The airflow is parallel to the path of the parts and through the space between the parts and the electrode.
- One or more grounded air spray guns are placed at the exit end of the booth.
- Arranged to form and project small droplets of the liquid between electrode and article
- Generally fog the material into moving exhaust stream and around article.
- When the voltage is applied to the electrode, an electric field is established to the article.
- This means that the article must be electrically conducting. If it is to serve as the other electrode in this field. Several techniques have been developed whereby an article that is not electrically conducting can be made adequately conductive, at least on its surface.
- If particles are not deposited due to motion of the article – they are carried into the exhaust plenum by the exhaust air.
- Extending the electrode along the path of the article, the charging and deposition forces have longer to act and so deposit a greater percentage of the particles.
- Single material- coated by wrap around actions electric field. Not completely uniform – liquid deposited continues to be electrically conducting.
- Coated and uncoated surfaces exhibit the same attraction for new material.
- Uniform coating - material must be distributed equally about the article and must experience equal attraction.

- Practically –
- Articles are supported from conveyor on a rotatable hook and are rotated by a friction drag as they are moved along by the conveyor. All surfaces are thus comparably presented to the field and to the spray, and uniform coatings are readily obtained.
- This captures atleast half the material that would be lost in normal air spray gun.
- Eg: Refrigerator – Air Spray gun – 40% (transfer efficiency)
 - ES spray gun – 70% (transfer efficiency)
 - Added advantage –wrapping effect of the electrostatic field
 - Edges and surfaces not in direct mechanical path of the spray methods are also coated.
 - The surfaces on the back of panel members immediately adjacent the edges likewise receive protective coating with this method without special effort.
 - Refrigerators
 - Automotive parts
 - Military hardware components
 - Waste baskets
 - Oil cans
 - Powder containers
 - Canister sets
 - Extremely thin oil coatings – electrolytic tin plate in continuous sheet form.
 - Starch solutions to paper webs to enhance surface properties
 - Flat sheets – extended plane electrode parallel series of guns introduce the material in the field.

Modifications-

- Spray guns spray material through the system directly towards the article on the conveyor.
- Electrode is mounted in front of the atomizer and the entire gun electrode assembly is charged to high voltage.
- Material is sprayed at the object across the conveyor path.
- Air atomization produces particles charged by ion bombardment carried into field by air stream.
- Deposited by mechanical velocity of electrostatic attraction.
-
- **Automatic No. 2 Process**
- No.1 - elaborated ES potential in coating
- Still the efficiency was not very good.
- Material lost with No.1 process
- Atomizing process blows particles beyond Efield control
- Need to avoid atomization
- Particles formed at high Efield by action of the field it self and charged then and there .
- This is termed No.2
- As applied to automatic coating operations, this process is used in three modifications; the blade, the bell, and the disc.

- **No. 2 Blade Modification**

- Not popular
- Best to illustrate ES aspects of No. 2 type units
- Atomizing head is a wedge – shaped electrically conducting member having a length comparable to the length of the spray pattern desired.
- The head is placed adjacent the surface to be coated at a spacing of about 1 ft..It is oriented so that its length is parallel to the surface and so that the sharpened edge of its wedge-shaped cross section is desired toward the surface. It is supported on insulators and held at a potential of approximately 100 kV with respect to the surface.
- On application of voltage Efield is created between object and head. – with high gradient at wedge edge and a low gradient at the object.
- Coating material pumped to the head: flows as a uniform exposed liquid film at the wedge edge where it is subjected to high electric field gradient
- Strongly attracted towards the object
- Field – forms the extended film into a liquid cusps – pointed liquid extensions spaced uniformly along the exposed length of the film.
- They reach out into the field due to attraction
- Liquid element(cusp)- becomes a charge centre – is attracted by the object and repelled by body of liquid on the atomizer.

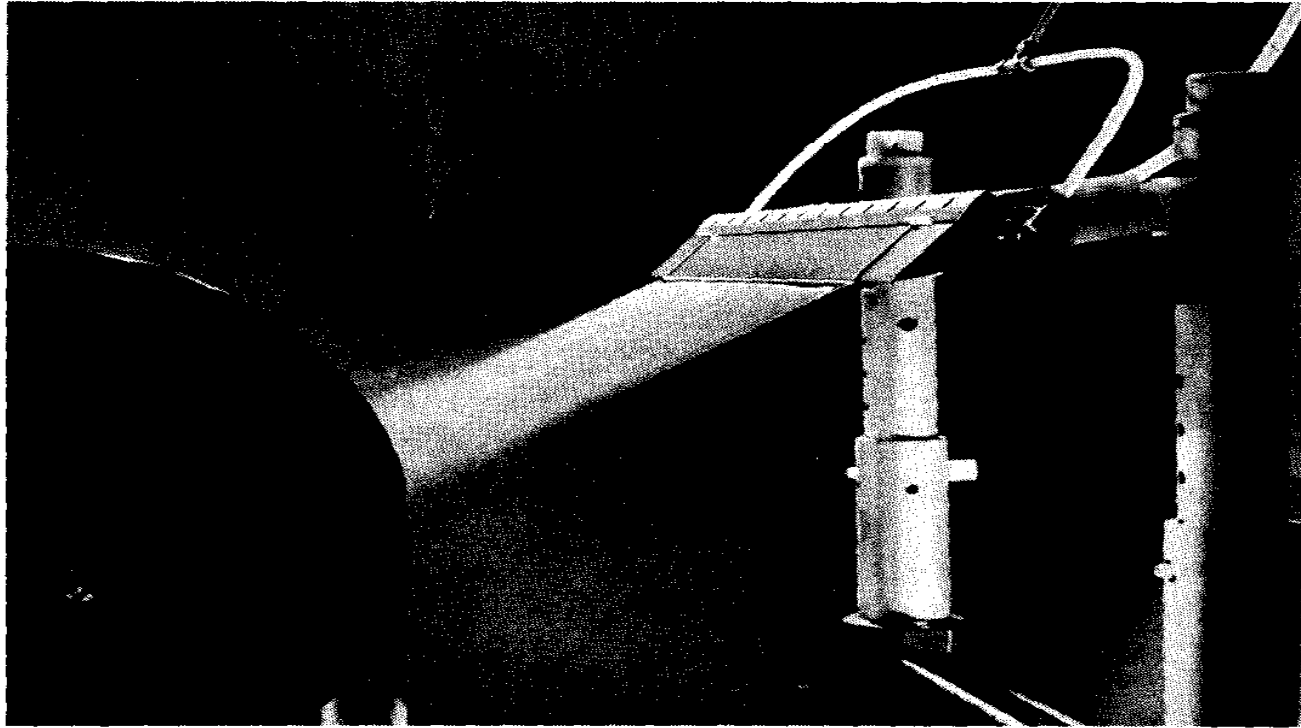
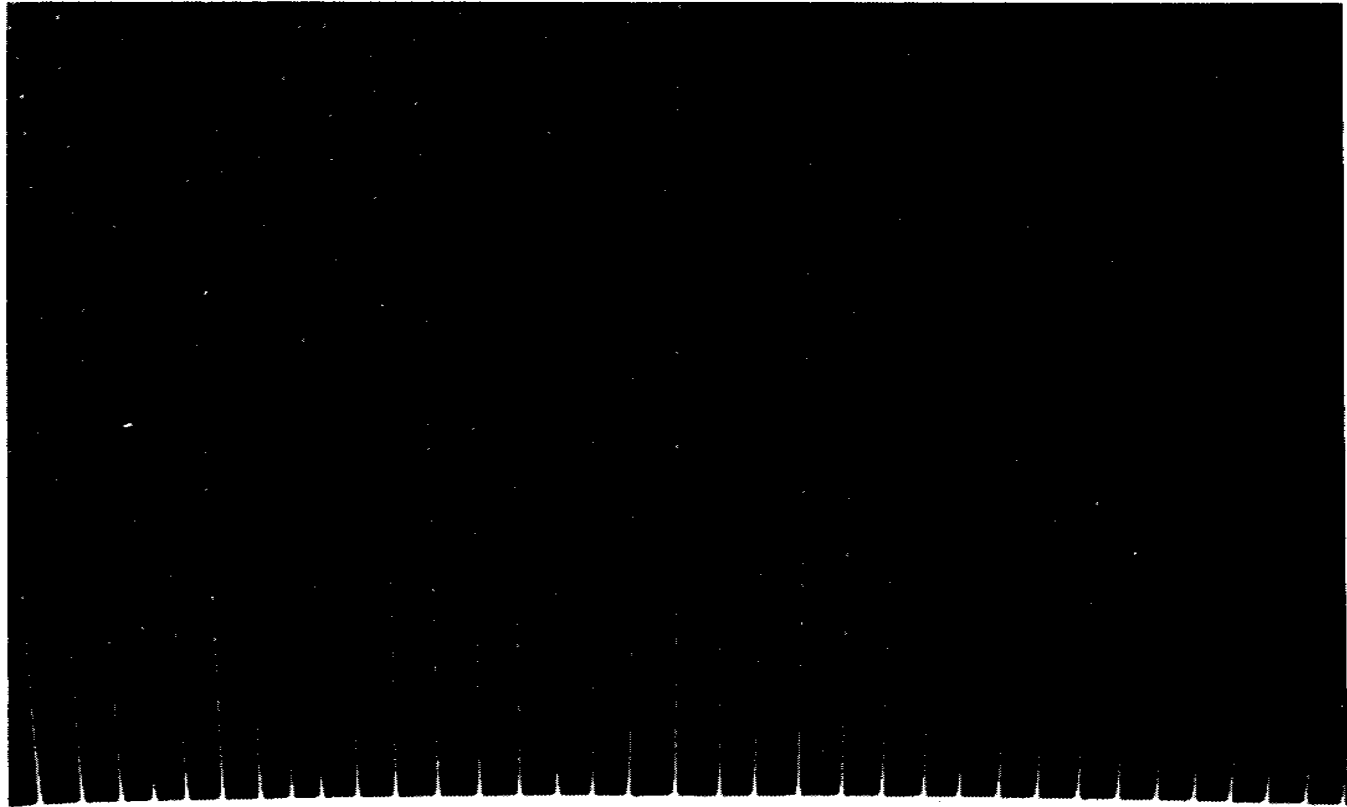


Figure 11.2. Electrostatic blade applying liquid coating to flat sheet stock.

- When repulsive force overcomes surface tension.
- These particles leave the head and travel along the field lines on to the object surface.
- Particles collect on the surface – charge flows through the object to ground. Particles flow and coalesce –forming a film.
- No second disturbing agent in particle formation.
- Particles charged by contact as they carry away appropriate portion of the charge on the edge. Being highly charged – deposited by strong deposition forces without any interference
- 100% deposition of the material leaving the head
- Condition at blade edge is stable one resulting from the combined action of the high voltage field, the quantity of material available, the electrical characteristics of the material, and the rheology of the material.
- For any specific quantity of material delivered at a constant rate to the edge, a stable condition of uniformly spaced liquid extension(see Fig. 11.3) will be established along the edge and charged particles of a rather narrow size distribution will be obtained.
- If voltage is raised – spacing reduces,
- They become shorter , smaller particles formed.
- 4 cm³/min/cm of edge length
- Long extended uniform pattern
- Large flat areas



Liquid cusps formed at blade edge by high-gradient electrostatic field.
Charged particles from cusps tips are visible.

No.2 Bell Modification

- Atomizer in the form of a bell/funnel mounted on a rotating motor about its axis .
- Outer edge at the open end of the bell is sharpened and directed towards the object to be coated.
- Bell/motor mounted on insulating support are held at HV
- Typical rpm is 900-3600
- Coating material is pumped to the internal surface of bell. Rotation causes uniform spread over the inside surface of the bell and to flow to the larger end. At the sharpened forward an extended thin film due to high field gradient due to the charge on the atomizer.
- Similar to blade – at the bell edge cusps are formed at equal spacings about the circumference of the bell.
- Spray of small charged liquid particles is produced which proceed to target along path – resultant – centrifugal and electrical forces
- Envelop of spray looks like an umbrella from head to the target
- On flat surface – doughnut pattern is depicted.
- Movement ensures – extended coated area
- Rotation helps better coat of the part.

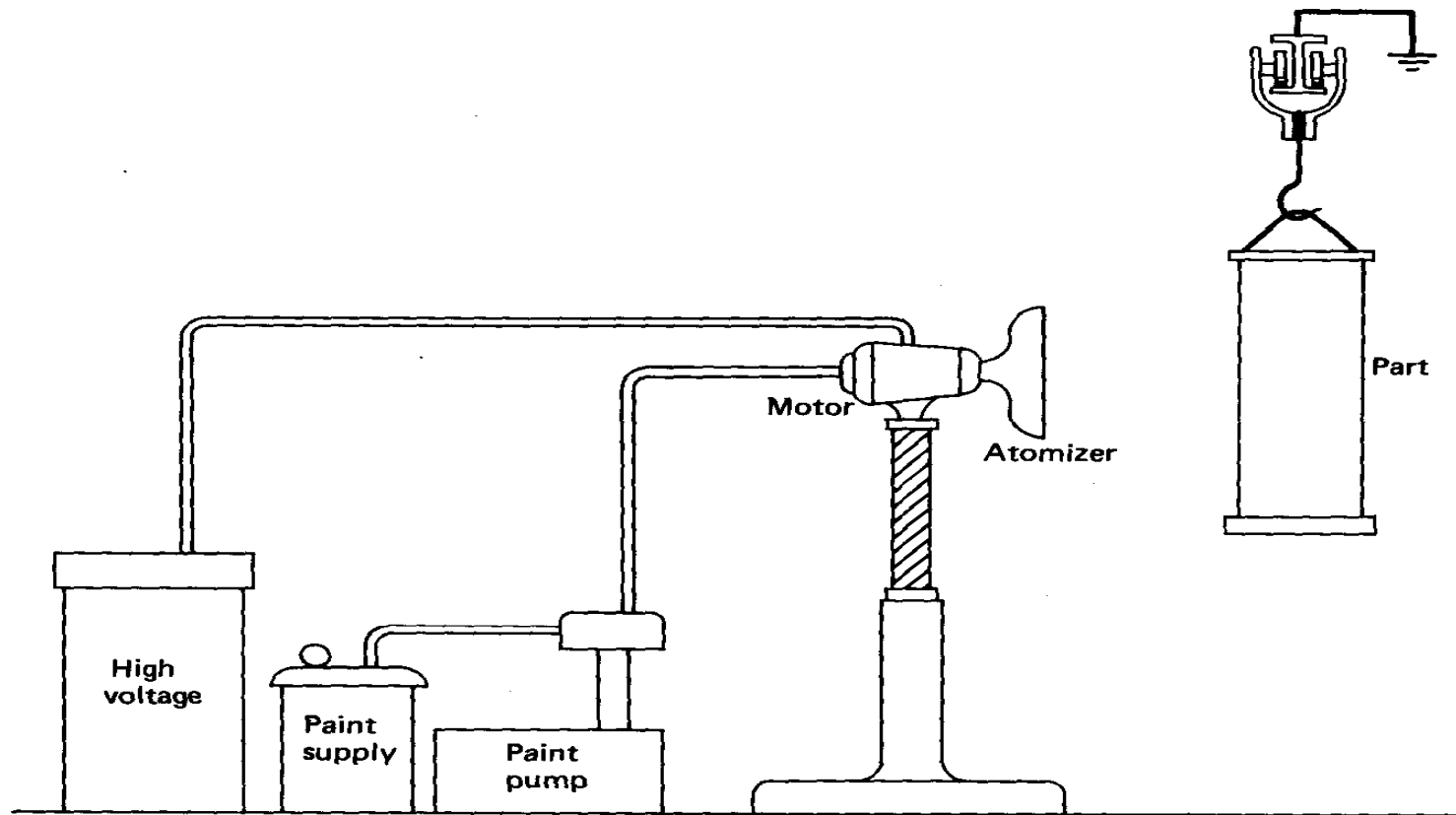


Figure 11.4. Schematic elevation of automatic No. 2 electrostatic bell coating installation.

No.2 Disc Modification

- No.2 disc modification – similar ES – bell and blade
- Atomizer – different
- Disc shaped element mounted on a drive – rotated about vertical axis – whose edge is sharpened mounted on an insulated support whole assembly placed at the center of a loop in the article carrying conveyor making an arc of about 300° about the disc.
- Disc rotated at 900-3600 rpm
- HVDC applied to disc creating field Diverging from disc to the article.
- Coating material pumped to the surface of rotating disc at its centre
- Rotation spreads material over the disc surface flowing to outer edge – where it appears as a thin extended 3600 film
- When no voltage is applied – material thrown after the disc edge – by pure mechanical forces
- Cusps formation is irregular – bulb
- On applⁿ of HV – gradient is high
- Film gets shaped into series of high cusps equally spaced around the disc perimeter
- Cusps extends into the field towards articles from their tips highly charged cloud of particles is atomized.

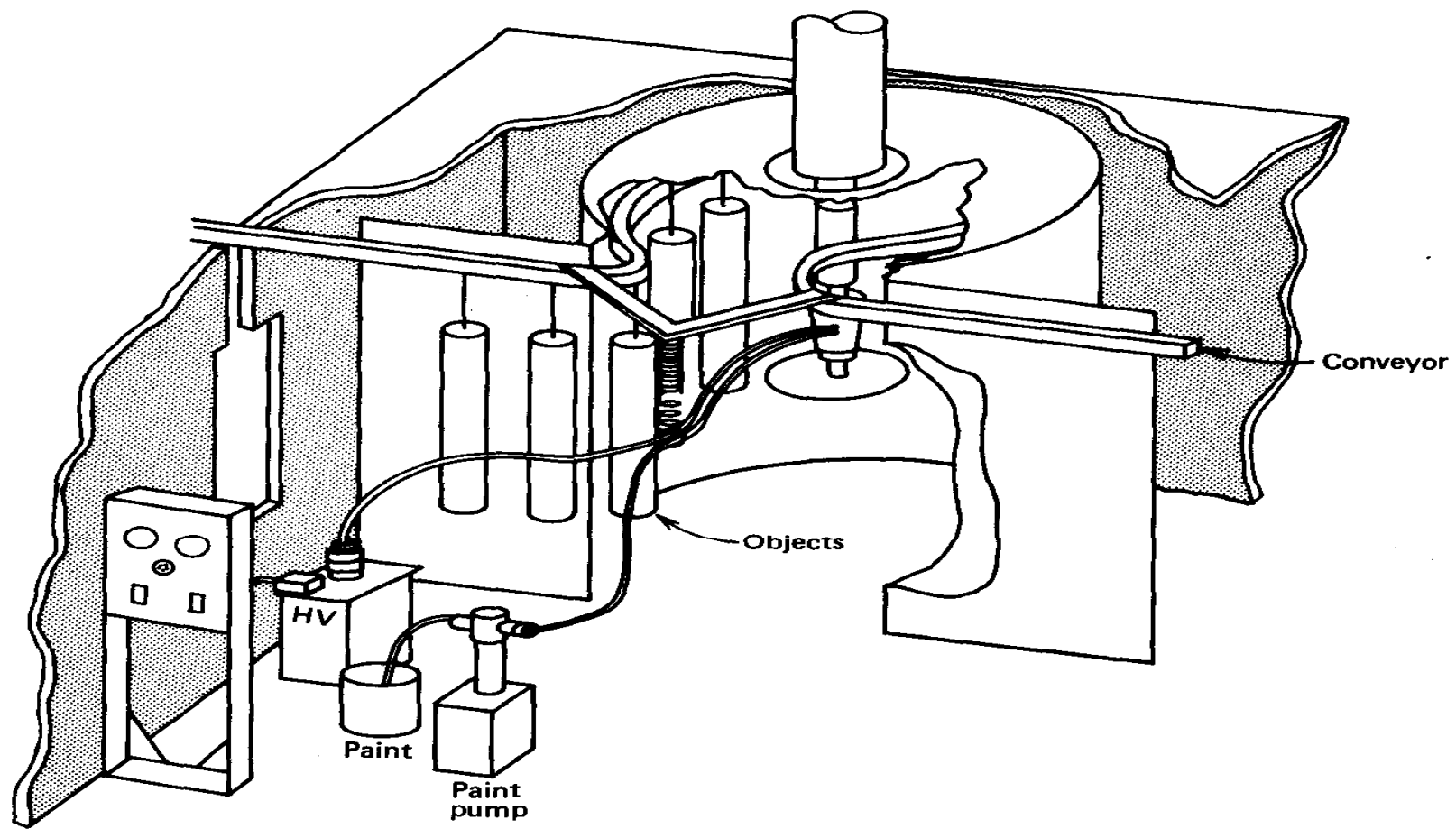
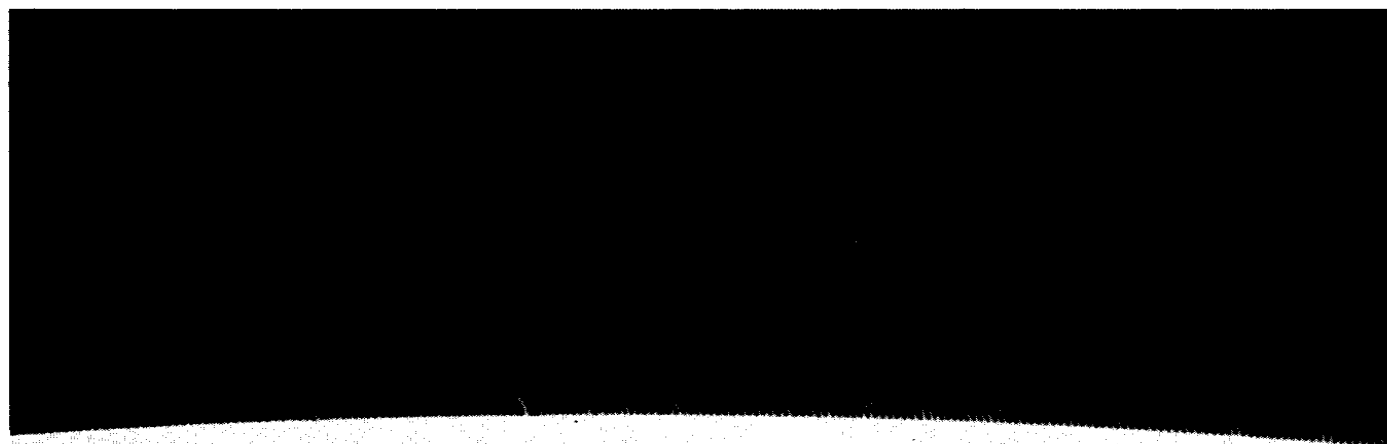


Figure 11.5. Schematic elevation of automatic No. 2 electrostatic disc coating installation.

- Particles move out into space – between disc and articles on the conveyor and follow a path to the article dictated by the resultant of the centrifugal and electrical forces.
- Since material is emitted from cusps around the entire disc circumference – they are coated from the time they enter until they leave the loop.
- Because particles are charged / dispersed – they don't land on an article as a narrow band.-unlike purely mech. Deposition but are deposited in a wide band.
- Space between disc and article of 12 in. ,the dispersion covers an article of 8 in. Height.
- For articles > 8 in. Height
- Disc and motor are mounted on a reciprocating mechanism – to move up and down along the axis of conveyor loop.
- A parts move the disc stroked up and down over the article height



(a)



(b)

Figure 11.6. Particle formation at rotating disc edge: (a) without electrostatic field applied; (b) with electrostatic field applied.

APPLICATIONS

- golf balls
- toilet seats
- automotive trim parts,
- oil filter containers
- acoustical panels
- bicycles
- folding metal chairs
- with these techniques 2.5 times as many parts per gallon of material as the ordinary spray guns.
- This increased production per unit of sprayed material obviously represents great savings in the manufacturing costs of the item and explain in part the great success which electrostatic coating methods have achieved.

ELECTROSTATIC HAND GUNS

- THE No.1 and No. 2 automatic deposition – parts carried to coating station – finished stock position.
- In the coating station the atomizers are in specific positions about the articles so that the charged material particles will be appropriately distributed about the articles to produce a satisfactory coating.
- Fully automatic – Remote control – Inflexible
- Hand held devices suitable there
- Manipulated by the operator
- Efficiency of ES – flexibility of hand held unit together.
- Operator needs to be protected
- HV required for ES effects – hand held device spacing can freely be altered should be free of discharger under these conditions
- 1. No.2 type electrostatic automatic units;
- 2. Air atomization or Hydrostatic atomization ion – bombardment.
-

No.2 Process Hand Gun

- Liquid – presented as thin film to HV field. – atomized by field – charged by contact (HV). Deposited by E field.
- Insulated elongated body with handle at one end and a rotating bell at the other end – bell made of insulator with surface of poor conductor rotated at about 600 rpm a motor in the gun near the handle.
- Coating material delivered to the rear side inside surface of the bell through a valve in the handle and a tube running lengthwise through the gun body.
- A HV cable extending at about 90 kV potential supplier by means of a sliding brush contact to the bell surface
- Coating on the bell conducts it to the forward edge.
- Atomizing bell – rotated – voltage applied pressurized coated material is fed to the rear of the bell.

- Manipulating gun over the surface of the article material is deposited by field on the surface.
- HV supply should have high internal impedance and its output fed to the bell through a high resistance
- Brush contact is kept very small
- Used for article refinishing field.
- H high – limitations
- Atomization – interaction of field with liquid film.
 - Electrical characteristics degree material matter
 - All materials do not respond well.
 - Some are too conducting and short the bell.
 - Too insulating – particles formation and charging are effected.
 - Not possible to deposit in that are shielded by Faraday Cage lead to air/Hydro air guns.

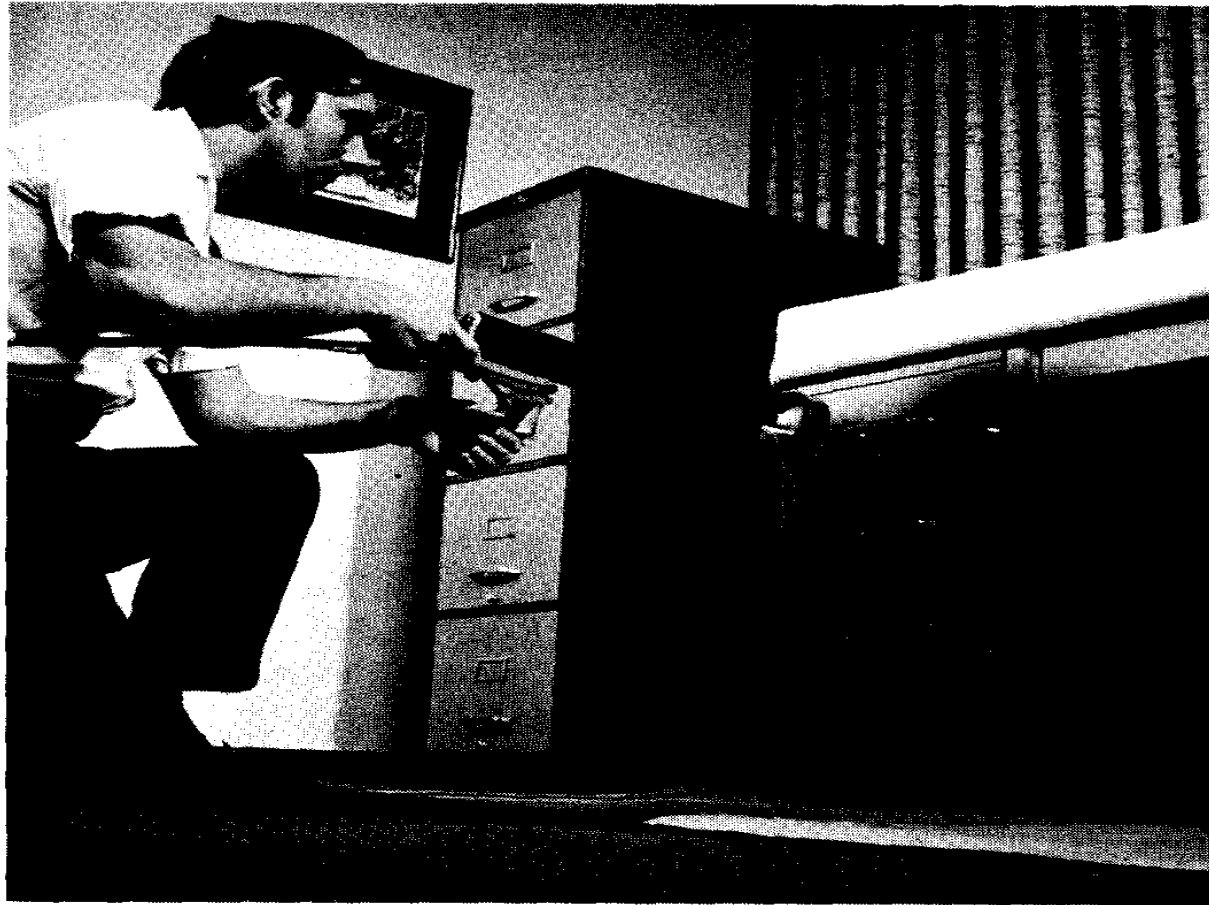


Figure 11.7. No. 2 electrostatic hand gun being used to finish office furniture.

AIR ATOMIZING HAND GUNS

- **Air** ES guns – body of insulating material with a normal grip type handle on one end and air cap,-fluid tip assembly on the other.
- **Latter components are made of insulating materials**
- Functions similar to normal spray guns similar in construction
- Liquid coating material exits at relatively low pressure as a liquid stream – atomized by air – from various air outlets in the air cap impinging on it. It is then projected outwards in the form of spray
- Fluid – air interaction produces spray of small particles
- Near the position of particle formation there is located on electrode at HV – small pointed wire within the body of the gun – liquid jet itself?
- Portable No. 1 type
- Charging element carried by the gun/moved with it over/about the object
- Charged spray particles projected away from the gun toward the surface

- Velocity/direction by atomizing air
- Pan through corona-formed – charged air particles get charged and attracted to the article
- Electrical attraction overcomes Mechanical movement
- Transfer η as high as 80%.
- 30 – 60 kV
- Cascade or ladder-type circuit from 110 V ac circuit (EGD)
- 4 – 6 kV by primary supply – multiplied to 60 kV
- High impedance values are chosen to prevent shock/discharge hazard to the operator – prevents discharge even when in direct contact.
- Electrodes having low capacities.

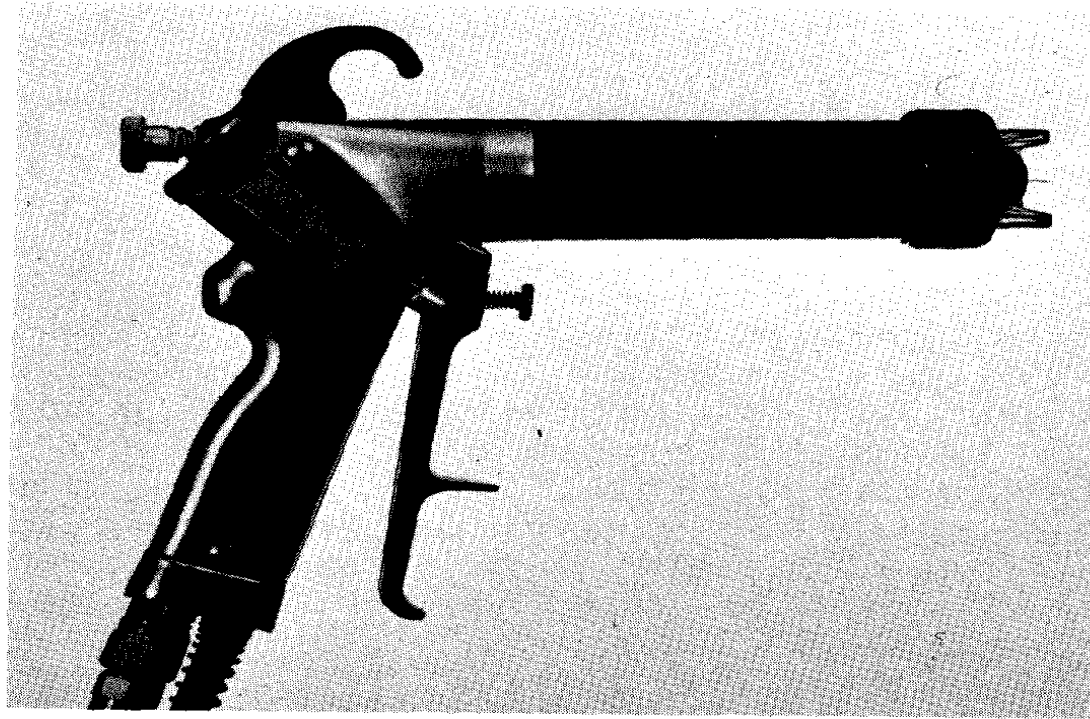


Figure 11.8. Typical electrostatic air hand gun.

HYDRAULIC ATOMIZING ELECTROSTATIC GUNS

- Hydraulic pressure instead of air is used – to atomize
- Main elongated body of insulating material.
- Handle at the end of the body
- On the forward end – extremely small orifice
- Liquid is atomized through this orifice
- Liquid is pumped from a reservoir to the gun at 1000 psi – is valved to the orifice by motion of a trigger on the gun
- As material is released – it atomizes into fine spray.
- By suitable shaping can make spray into fan shape.
- Sharp pointed wire electrode charged to HV terminates near the point of particle format
- Corona formed at the electrode charges the particles formed forming an ionic cloud
- Charged particles move under the influence of mechanical momentum and electrical attraction due to their charge.
- As air blast is absent mechanical momentum dissipates quickly – Electric field has good control over the particles
- H transfer > that with air. Electrostatic guns
- They are not flexible – pattern adjustment, delivery control and degree of atomization
- Not widely accepted
- Modified versions – air and hydraulic – automated coating systems.
-

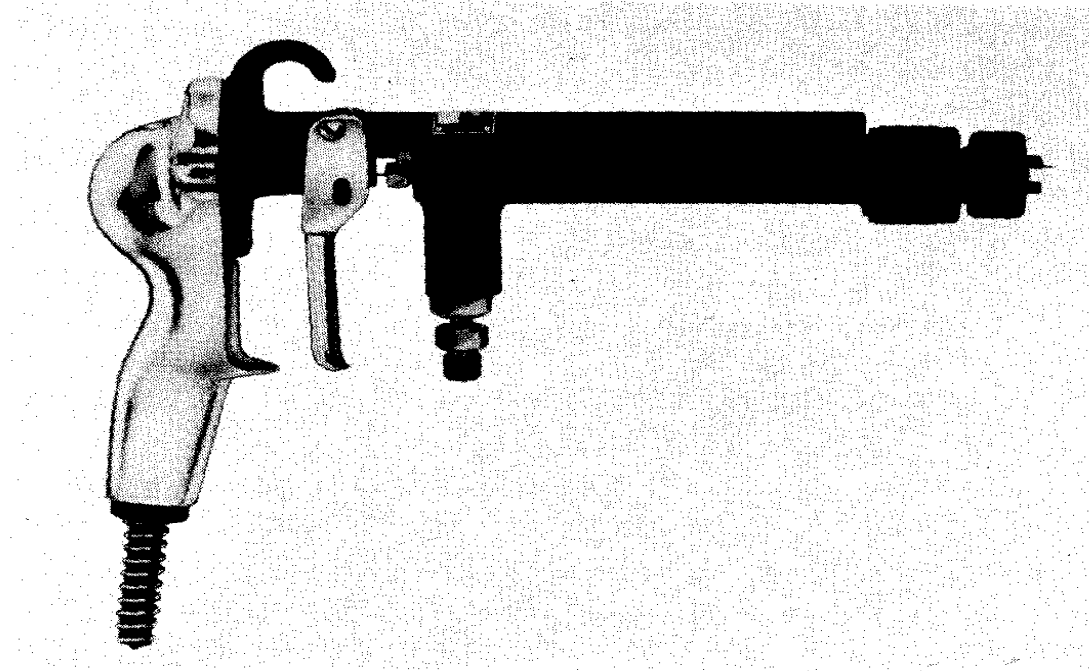


Figure 11.9. Typical electrostatic hydraulic hand gun.

LIQUID ES COATING IN UNUSUAL PROCESS

- Air ES Guns – Metallic organic compound spraying on the surface of hot glass objects . The compound decomposes on the hot surface imparting a metallic lustre with a chr. Color. These colors are expensive and hence warrant ES applications.
- **ES BELL TYPE** -
- Polyurethane sheet – elastomeric chr. Sprayed on a flat surface.
- As the field gradient is high at the edge of the bell material is elongated into filament shaped elements
- Due to E field, elements become unstable and break.
- They are attracted by the oppositely charged flat surface
- Due to the rotation – filaments are deposited in jack straw fashion – crossing over one another adhering at their intersection
- The random deposition – imports a non directional strength to the porous sheet formed as fibres solidify.
- This is then stripped and used as non woven synthetic cloth.
- Liquid insecticides spraying on growing plants.
- Liquid particles charged / dispersed from ES guns carried tractors/ air borne vehicles

SOLID ES COATING

- Many industrial coating applications do not involve the deposition of liquid particles but are concerned with depositing dry particulate materials which are powdered or dustlike.
- The basic concepts of Coulomb's law can be applied.
- If the particles can be distributed about the surface to be coated and given an electrical charge which is opposite to the surface, they will be urged towards the surface and will be deposited there as an effective coating.
- This elementary concept has been elaborated on in many respects to fit the demands of many industrial operations.
- Electrostatic deposition of many kinds of dry particulate material is being used to help solve many industrial coating problems.

Electrostatic Formation of Sandpaper

- One of the earliest large-scale applications of electrostatic forces in the manufacture of a product that involved the deposition of a dry powderlike material as the manufacture of sandpaper or similar abrasive items.
- In this process two extended flat electrodes, are positioned parallel to each other at a separation of about 4in. And are insulated so they can be charged with respect to each other in the manner of two plates of an air dielectric condenser.
- A continuous belt of semiconducting material passes over a group of rolls and is in contact with the upper surface of the lower electrode plate.
- The paper or textile web, which is to become the backing for the abrasive product, is fed from a roll through a glue applicator which places a layer of adhesive on its one face. The web then passes through the spacing between the electrodes with its glued surface facing downward and with its other surface in contact with the upper electrode. The electrodes may be of special design, depending on the imagination of the builder;
- A dc voltage in the neighbourhood of 100 kV is applied across the two electrodes.

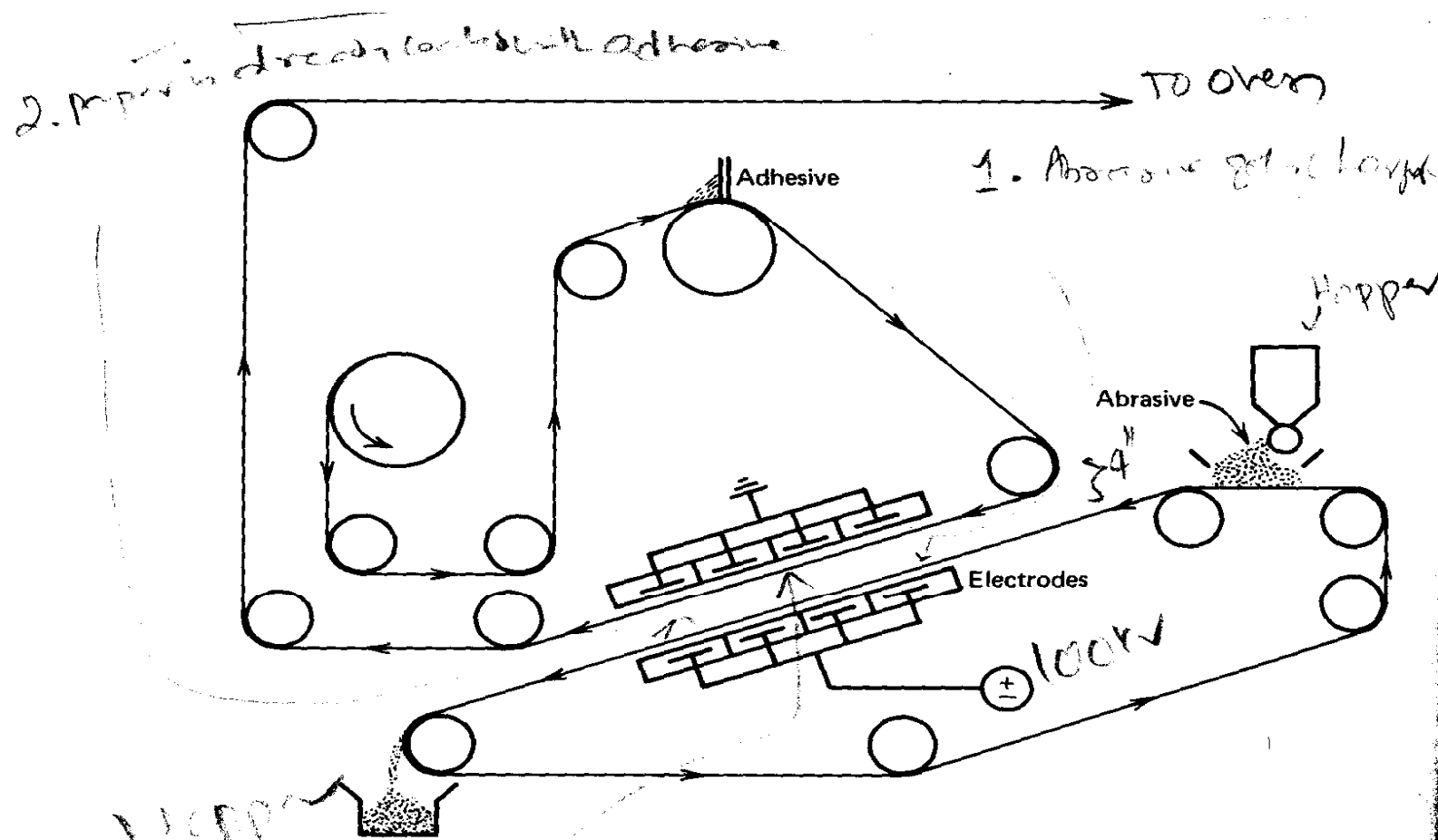


Figure 11.10. Schematic of electrostatic equipment for manufacture of abrasive papers.

- The ground frit-agate, sand, or other dry material forming the abrasive component of the product-is distributed over the surface of the lower moving belt by a hopper feed mechanism at a point outside the electrodes.
- The belt carries this material on its surface into the space between the electrodes. Simultaneously the glued surface web is also moving through this space.
- When the material on the lower belt arrives over the surface of the electrode; it becomes charged by contact to the same sign as the electrode.
- It is repelled from the lower electrode and attracted toward the upper one.
- If the forces are large then each particle will be moved upward.
- At the top electrode the glued paper backing intercepts the flight of the particles and they are imbedded in the glue.
- It will become charged to the sign of the top electrode and will be repelled toward the bottom belt.
- Upon hitting the belt it again has its sign reversed and makes a second trip to the glue layer.

ES Fluidized Bed

- The ES fluidized bed was the earliest method featuring electrostatic deposition of resin powders on the articles to produce commercially acceptable finishes.
- From fig 11.11, the powdered resin is fluidized in a normal mechanical fluidizing bed.
- A series of charging electrodes is immersed in the fluidized powder. When these electrodes are connected to a high voltage , a corona is produced at their tips or points.
- The corona creates air ions which charge the powder particles in the bed by ion bombardment.
- Under the action of this charge they repel one another and are attracted to any grounded surface in the vicinity.
- A conducting object held above the charged powder in the bed becomes such a surface and quickly accumulates a powder layer on its surface.
- If the object surface is heated, the attraction still exists.
- Under these conditions the particles hitting the surface are fused and melted onto the surface.

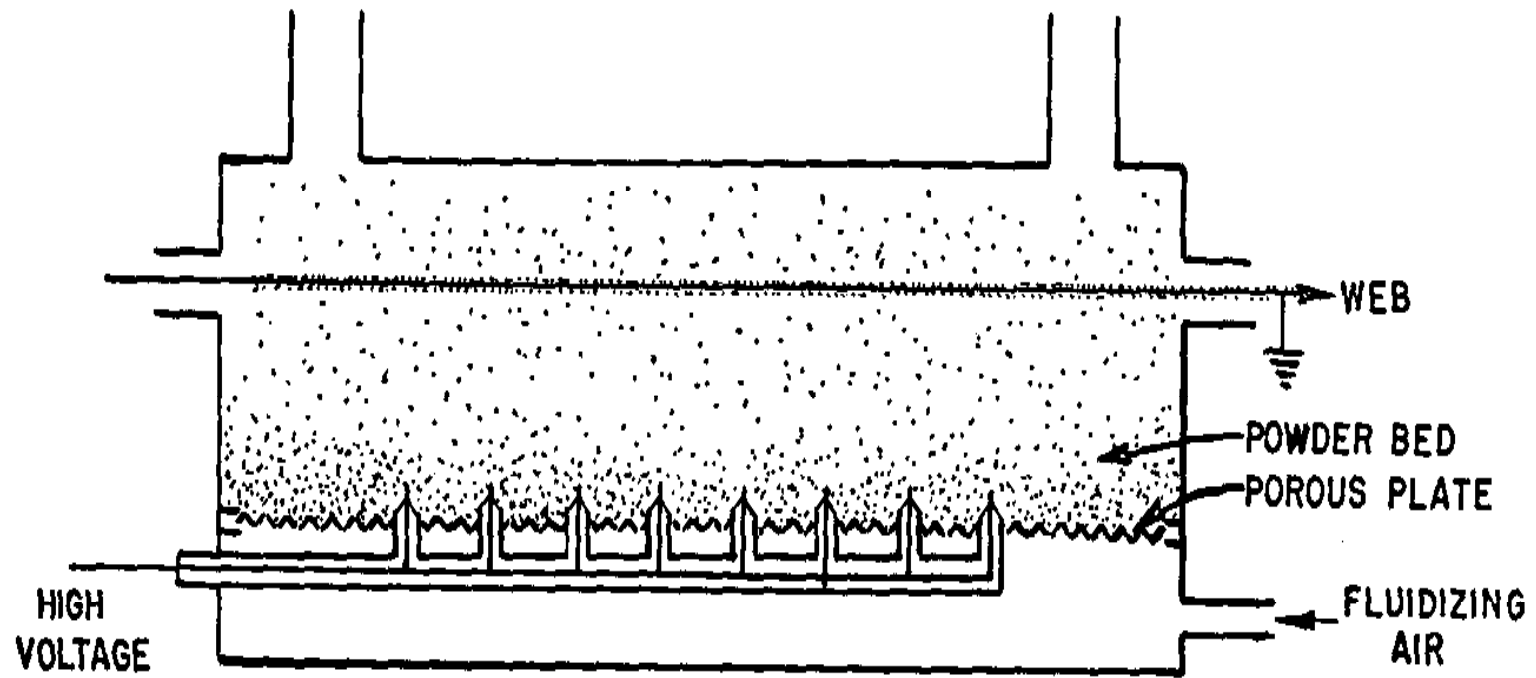


Figure 11.11. Electrostatic fluidized bed.

ES Powder Hand Guns

- The limitations of the electrostatic fluidized bed, insofar as it is a fixed-position applicator, have been overcome by another recently introduced method.
- Hand-held devices, such as the one in fig. 11.12, have been developed which receive the powder from a suitable supply, charge it, and dispense it as a charged powder cloud over and about the object being coated at the discretion of the holder. This material is then attracted to the surface to form the coating.
- The object being coated can be heated or unheated, as desired.
- In the case of unheated particle, the charge accumulation creates a self-limiting film acceptance.
- The charging elements are usually held at about 60kV direct potential with respect to the oppositely disposed surface. These voltage supplies usually have negative output and are adjustable from 0 to 60 kV.
- There is some evidence, although it is not fully conclusive, that some powder materials are more effectively applied by using one polarity than with the other.

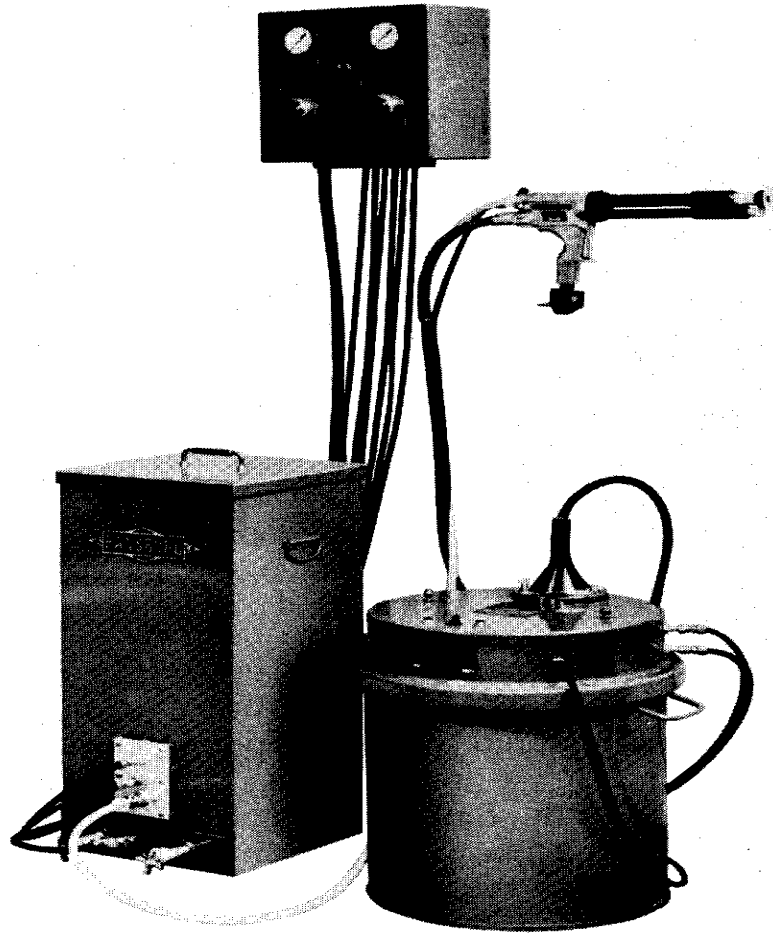


Figure 11.12. Typical electrostatic powder hand gun.

- Using hand electrostatic powder methods it is possible to accumulate about 80% of the powder dispensed from the gun on the surface. The other 20% escapes deposition in any one application, but it can be recaptured in a cyclone – or bag-type filter.
- If the material collected is kept in an uncontaminated condition, it can be reused in the equipment, thus obtaining overall efficiencies close to 98 to 99%.
- The ultimate film thickness obtainable as well as the overall efficiency of deposition is closely related to the electrical properties of the powder
- If the powder accepts the charge readily it will be very effectively deposited.
- If the powder loses its charge easily, the film that can be accumulated on a cold surface may be extremely variable.
- If the powder is highly resistive and holds its charge for a long time, then only a very thin film may be obtained.
- A powder that would deposit at near – 100% efficiency would be ideal because such a rate would avoid all the troubles connected with the reclaiming and reuse.