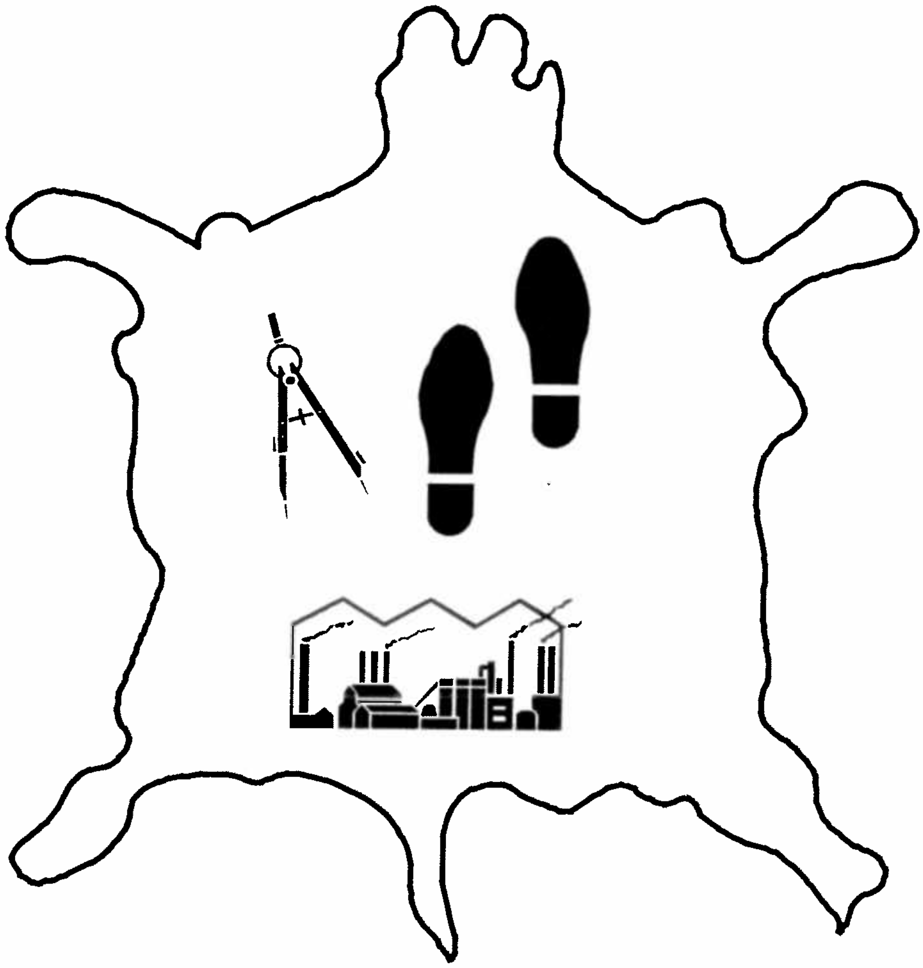
SHOE INDUSTRY
CERTIFICATE COURSE

UNIDO

ELEMENTS OF PHYSICS*



* This document has been produced without formal editing

This learning element was developed by the UNIDO Leather Unit's staff, its experts and the consultants of the Clothing and Footwear Institute (UK) for the project US/PHI/85/109 and is a part of a complete Footwear Industry Certificate course. The material is made available to other UNIDO projects and may be used by UNIDO experts as training aid and given, fully or partly, as hand-out for students and trainees.

The complete Certificate Course includes the following learning elements:

Certificate course

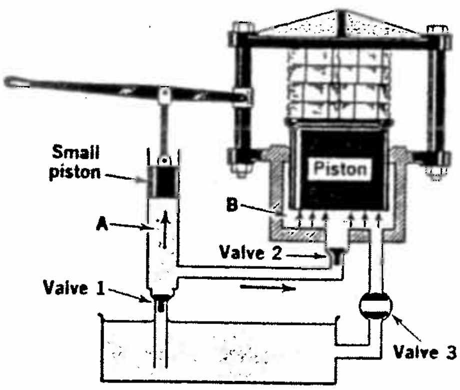
-Feet and last
-Basic design
-Pattern cutting
-Upper clicking
-Closing
-Making
-Textiles and synthetic materials
-Elastomers and plastomers
-Purchasing and storing
-Quality determination and control
-Elements of physics
-General management
-Production management
-Industrial Law
-Industrial accountancy
-Electricity and applied mechanics
-Economics
-SI metric system of measurement
-Marketing
-Mathematics
-Elements of chemistry

FOOTWEAR AND LEATHERGOODS INDUSTRY CENTER

STAFF DEVELOPMENT PROGRAM

Sir Isaac Newton (1642–1727)

ELEMENTS OF PHYSICS



FLIC/CFI
20.2.

TABLE OF CONTENT

Elements of Physics

I. GENERAL PROPERTIES OF MATTER

Physics is the science which deals with matter and energy and their physical transformations without alteration of the molecule.

Matter is anything which occupies space and has weight

Energy is the ability to do work and appears as heat, electricity, light sound, mechanical energy and nuclear energy

Some properties of matter

1. matter exists as solids, liquids and gases
2. volume is the measure of the amount of space which matter occupies
3. weight is the force by which the earth attracts one object. It varies from place to place on the earth and is zero in outer space where weightlessness is experienced.
4. mass is the quantity of matter contained in an object and remains constant at all parts of the earth and in outer space
5. divisibility matter can be subdivided in particles having all the properties of the original substance.
6. porosity is the property of having many small openings or spaces
7. compressibility is the property of reducing the volume under pressure.
8. elasticity is the property of matter that requires a force to produce distorsion and when the force is removed, causes the material to resume its original shape.
9. plasticity is the part of the distorsion that will not resume the original shape of an object when the force is removed.

There are different kinds of elasticity

- the elasticity of traction
- the elasticity of torsion
- the elasticity of compression
- the elasticity of flexion

Liquids and gases show only elasticity of compression.

note matter and energy are related by the equation $E = mc^2$ (Einstein)

where E = amount of energy

m = amount of mass

c = velocity of light

Matter and energy are interchangeable; the total amount of energy and matter in the universe is constant. If energy appears, some matter disappears. If energy disappears matter must appear in its place (relativity)

II. FORCE and MOTION

FORCE is that which produces or prevents motion or has the tendency to do so.

FORCE is directly related to work and energy.

Some combinations of forces just balance each other; as a result, the body on which they act remains stationary.

In other cases, balanced forces may act on a body moving at a constant speed in a straight line.

A force acting on a body may also increase or decrease its speed or change its direction.

A force may move the particles of which a body is composed and thus change its shape.

The force of gravitation exerted by the earth causes bodies to fall toward the earth. We measure if when we find the weight of an object. Forces are measured by a spring balance or a dynamometer.

COMPOSITION OF FORCES

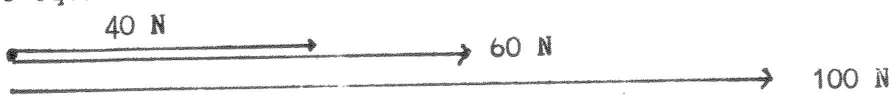
Forces are vector quantities.

A VECTOR is a quantity that has magnitude and direction. It is commonly represented by a directed line segment whose length represent the magnitude and whose orientation (arrow) in space represent the direction.

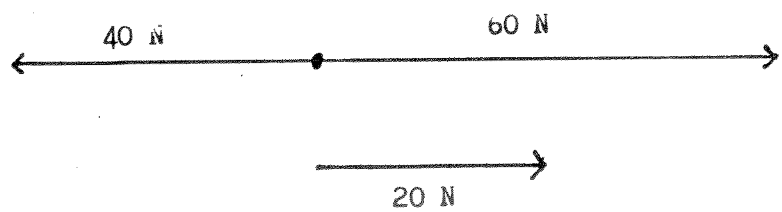
The RESULTANT of a force.

When two or more forces act concurrently at a point, the resultant force is that single force applied at the same point which should produce the same effect.

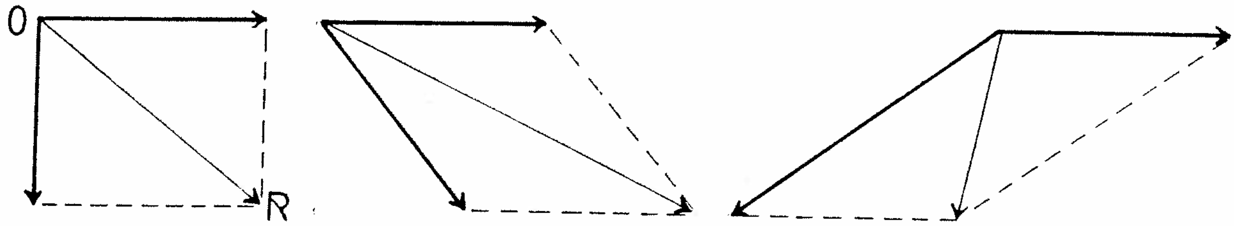
The resultant of two forces acting in the same direction on the same point has a magnitude equal to the sum of the forces and acts in the same direction.



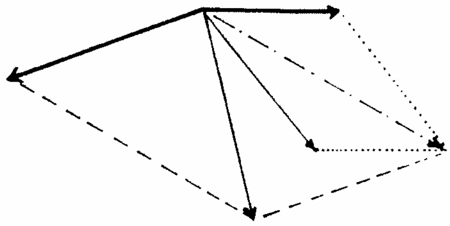
The resultant of two forces acting in opposite directions upon the same point has a magnitude equal to the algebraic sum of the forces and acts in the direction of the greater force.



The resultant of two forces acting at an angle of between 0° and 180° upon a given point is equal to the diagonal of a parallelogram of which the two force vectors are sides (geometric addition)



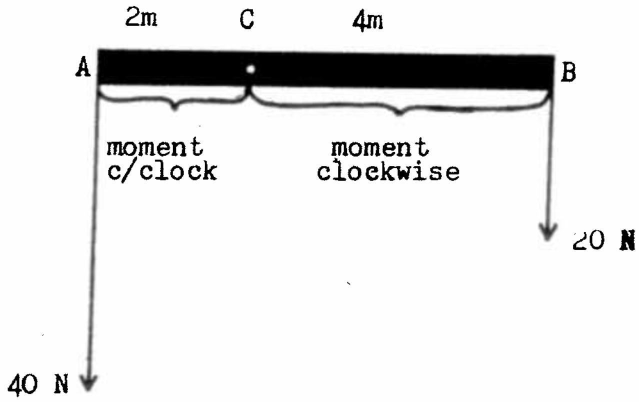
When three or more forces act a different angles upon the same point, the resultant is the diagonal of the successive parallelograms.



EQUILIBRIUM is the state of a body in which there is no change in its motion

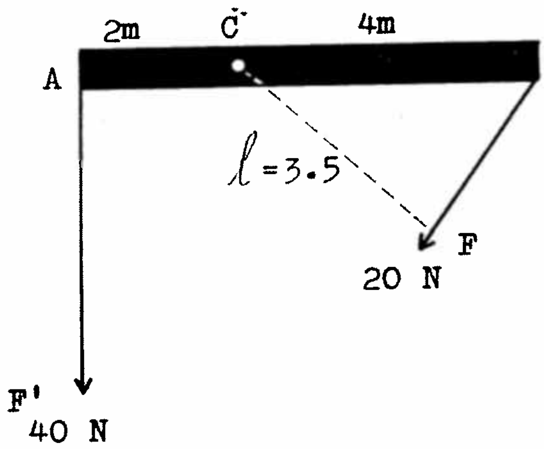
Parallel forces act in the same or opposite directions. The resultant of parallel forces has a magnitude equal to the algebraic sum of all the forces. The resultant acts in the direction of this force.

The moment of a force, or its TORQUE, equals the product of the force and the length of the moment arm on which it acts. The length of the moment arm is measured perpendicularly from the pivot point to the line of action of the force. The pivot point serves as the center of moments, the point from which the lengths of all moment arms are measured.



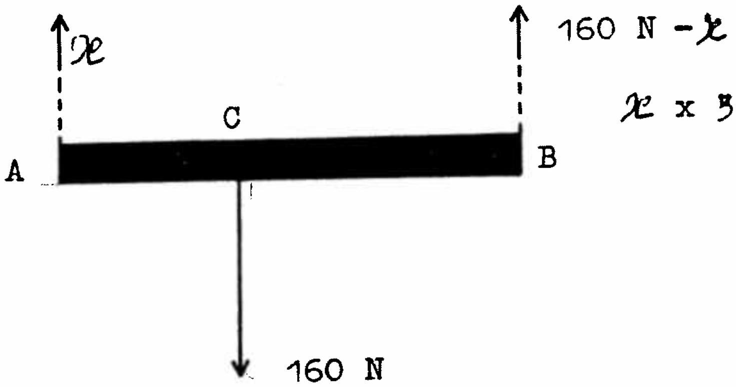
20 N x 4 m = torque 80 N m

40 N x 2 m = torque 80 N m

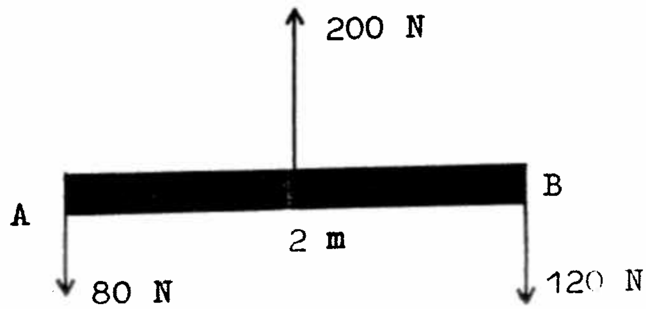


torque = 20 N x 3.5 m

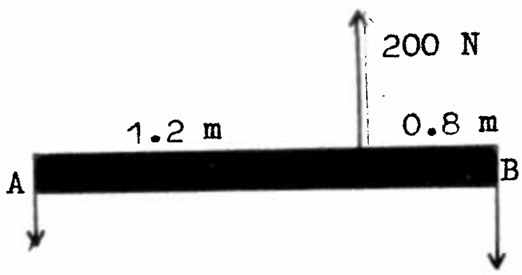
equilibrium



$x \times 3\ m = (160 - x) . 5m$



equilibrium



80 N x 1.2 m = 96

120 N x 0.8 m = 96

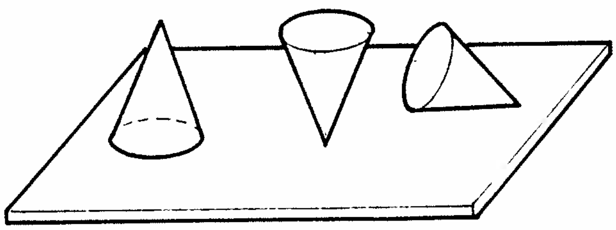
A pair of forces of equal magnitude acting in opposite directions but not in the same line is called a couple.

A couple of forces will move a wheel, a poulie, a corkscrew.

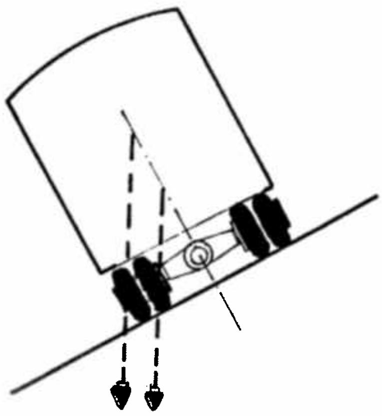
The center of gravity of any body is that point at which all of the weight of the body may be considered to be concentrated.

Equilibrium may be stable, unstable or neutral.

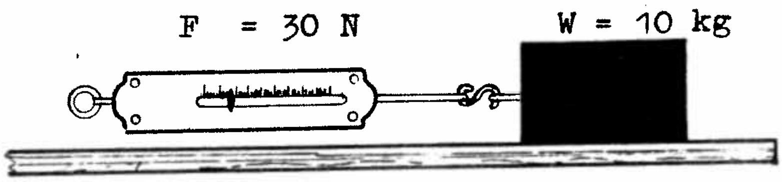
The stability of an object may be increased by enlarging the base, and by lowering the center of gravity as far as possible.



stable unstable neutral



FRICTION is a force which opposes motion. The coefficient of friction is the ratio of the force needed to overcome friction to the normal force pressing the surfaces together.



$$\mu = \frac{F}{W} = \frac{30}{10} = 3$$

III. MOTION

Motion is a continuing change of place or position

Velocity is the rate of displacement and

Acceleration is the rate of change of velocity

The relationship between initial and final velocity, acceleration, time and displacement may be expressed mathematically for uniformly accelerated motion.

$$v_{av} = \frac{p_f - p_i}{t_f - t_i} = \frac{m}{s}$$

A displacement is the result of motion.

Linear motion may be defined as motion in a straight line.

Rotary motion is a motion about an axis.

Newton's laws of motion are:

1. a body continues in its state of rest or uniform motion unless an unbalanced force acts on it. Consequence a body cannot change its state of rest or motion by himself. The property of matter which defines that a force be exerted on a body to accelerate it (move it) is called inertia.

2. the accelaration of a body is directly proportional to the force exerted on it, is inversely proportional to its mass, and in the same direction as the force.

$$a = \frac{F}{kg}$$

3. for every action there is an equal and opposite reaction

The force of gravitational attraction is the mutual force of attraction between bodies.

Law of universal gravitation (Newton)

Every particle in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

$$F = G \frac{kg \times kg}{m^2}$$

CIRCULAR MOTION

Uniform circular motion is motion at constant speed along a curved pa. th of constant radius.

If the speed of the object in the circular path varies, its motion becomes a variable circular motion.

As the object moves in the circular path with constant speed its direction is continually changing and because of the law of inertia a force is directed toward the center of the circle. That force of acceleration is called the centripetal force.

Because of the law of action and reaction , the centripetal force is balanced by an equal and opposed force : the centrifugal force.

Rotary motion is the motion of a body turning about an axis (wheel or pulley).

Note the difference between circular and rotary motion. In circular motion, the object as a whole travels along a circular path (satellite on a circular orbit).

In a rotary motion, the object spins.

Angular velocity is defined as the rate of angular displacement. Angular displacement is the angle about the axis of rotation through which the object turns.

formula $$\omega = \frac{\theta}{t}$$

in which ω is the angular velocity

θ is the angular displacement

t is time interval in which the angular displacement occurs

Angular velocity is measured in revolutions per second, or in degrees per second or in radians per second.

An angle of 1 radian is that angle which, when placed with its vertex at the center of a circle, subtends on the circonference an arc equal in length to the radius of the circle.

$$1 \text{ revolution} = 360^\circ = 2\pi \text{ radian}$$

IV. WORK - POWER - ENERGY

WORK is done when a force acts on matter and changes its motion.

In every day language the word WORK is used to describe any activity in which muscular or mental effort is exerted.

In physics, the word WORK is restricted to the result of an exerted force which moves an object.

The unit of work is the "joule" J it is the force of one newton acting through a distance of one meter.

The joule is the work done when the point of application of a force of 1 N is displaced through a distance of one meter in the direction of the force.

$$J = N\ m$$

The previous unit was the "erg" equal to one dyne per centimeter.
$1\ J = 10^7$ ergs

POWER is the time rate of doing work.

A man does the same amount of work whether he climbs a flight of stairs in one minute or in one hour, but he does not use the same amount of power.

Power depends upon three factos :

- the displacement of the object,
- the component of the force in the direction of the displacement,
- the time required.

The unit of power $\left(\text{Power} = \frac{\text{work}}{\text{time}}\right)$ is the watt.

$$1\ W = 1\ \frac{J}{s}$$

The previous unit was the Horse Power HP

One Horse Power is the power of a machine producing a work of 75 kg per second.

$$1\ HP = 75\ \frac{kg}{s} = 9,81 \times 75 \text{ watts} = 735.75\ W = 736\ W$$

$$(\ 1\ kg = 9.81\ J\ )$$

$$1\ HP = 0.736\ kw = \pm\ 3/4\ kW$$

ENERGY

Matter acquires energy when work is done against gravity in raising it to an elevated position or when work is done to set it in motion. The energy thus acquired can be used to do work.

"Energy of matter is the capacity to produce work"

There are two kinds of energy:

Kinetic energy is energy due to the motion of a mass (bullet, wind, waterfall)

Unit of kinetic energy is the gray Gy

$$1\ \text{Gy} = 1\ \frac{\text{J}}{\text{kg}}$$

Potential energy is stored energy or energy due to the position or configuration of a mass.
(stone, coiled spring, water tank)

Potential Energy = kg x g x h

where $g = 9.8\ m/sec^2$

$h = h_1 - h_o$ m

Note Matter and energy are interchangeable. The Einstein equation for the relation between matter and energy is

$$E = mc^2$$

where E is energy in joules, m is mass in kg and c is the speed of light 3×10^8 m sec

One of the basic steps in the reasoning which results in the Einstein equation is the idea that the mass of an object varies with its speed. At the ordinary speeds attained by matter, the variation of mass is so slight we cannot detect it. However at speeds near that of the light, the increase of mass is appreciable.

MACHINES

Machines are used to :

1. transform energy

   A generator transform mechanical energy into electric energy. Steam or gas turbine transforms heat energy into mechanical energy.

2. transfer energy from one place to another.

   The connecting rods, crankshaft, and rear axle transfer energy from the combustion in the cylinders of an automobile to the wheels.

3. multiply force

   system of pulleys, levers, etc.

4. multiply speed (or reduce)

   gears, transmissions, etc. breaks, friction, etc.
   No machine can be used to gain both force and speed at the same time.
   (greater speed = greater force)

5. change the direction of a force.

There are six simple machines:

- the lever
- the pulley } levers
- the wheel and axle }
- the inclined plan
- the screw } modified inclined planes
- the wedge }

The mechanical advantage of force of a machine may be defined by :

(i) ideal mechanical advantage IMA

is the ratio of the distance the effort force moves to the distance the resistance force moves

$$IMA = \frac{S_E}{S_R}$$

(ii) actual mechanical advantage AMA

is the ratio of the resistance force to the effort force.

$$AMA = \frac{F_R}{F_E}$$

Efficiency of machines

The efficiency of any machine is the ratio of its actual mechanical advantage to its ideal mechanical advantage, converted into a percentage.

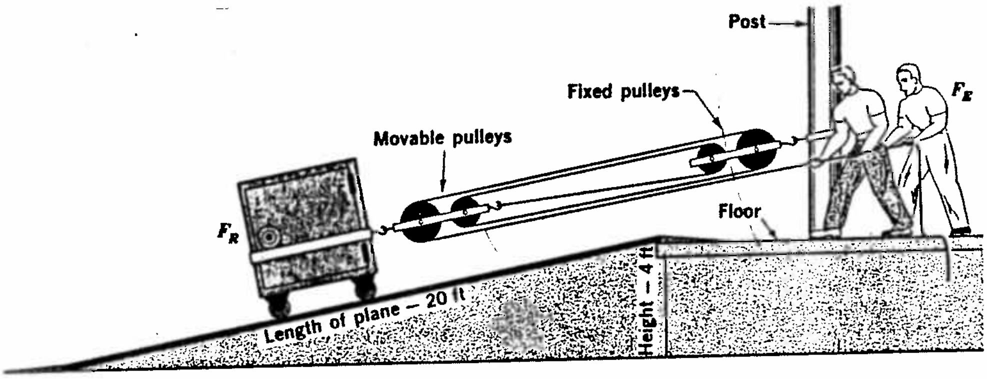
$$\text{efficiency} = \frac{AMA}{IMA} \times 100\ \%$$

Because force is required to move the parts of machine and to overcome friction in the machine, the AMA is never as great as the IMA and the efficiency of a machine is always less than 100%.

$$\frac{AMA}{IMA} = \frac{F_R\ /\ F_E}{S_E\ /\ S_R} \qquad AMA = \frac{F_R S_R}{F_E S_E}$$

The product $F_R S_R$ is the work done by the machine or the output,

the product $F_E S_E$ is the work put into the machine



The ideal mechanical advantage of a compound machine is usually the product of the ideal mechanical advantages of the simple machines that compose it. What is the ideal mechanical advantage of this compound machine?

V. KINETIC OF MATTER

The kinetic theory helps explain the properties of matter in terms of the forces between molecules and the energy they possess.

The three basic assumptions of the kinetic theory are:

1. Matter is composed of molecules.
   The chemical properties of molecules depend on their composition.
   The physical properties of molecules depend on the forces they exert on each other and the distance separating them.
   Molecules are composed of atoms. Atoms have a dense central nucleus which contains protons and neutrons and which is surrounded by a cloud of electrons arranged in shells or energy levels.

2. Molecules are in constant motion, their kinetic energy depends on the temperature.

3. Molecules obey Newton's laws of motion (conservation of energy)

There are forces acting between the molecules.
Considerable force is required to pull a solid apart, obviously the forces between the molecules of a solid must be great.
Liquids easily separate into drops indicating that the molecular forces in a liquid are not so great as in a solid.
In gases, molecules separate from each other spontaneously indicating that the forces between molecules are negligible. The forces between molecules decrease as the distance between them increases.

SOLIDS

Some of the properties of solids which depend on the molecular forces or molecular motion are:

Diffusion : penetration of one type of particle into a mass consisting of a second type of particles (gold and lead, hot melt and leather)

Cohesion and adhesion : The general term for the force of attraction between molecules of the same kind is cohesion.
Adhesion is the force of attraction between molecules of different kinds (adhesive to leather or rubber)

Tensile strength of a material is the force required to break a piece of that material having a unit cross-sectional area.

Ductility and malleability : When metals can be drawn to produce a wire, the metal is said to be ductile or to possess ductility.
When metals can be hammered or rolled, they are malleable or have malleability.
Elastomeres are malleable.

Elasticity : A solid which requires a certain amount of force to distort (or stretch) it and then tends to resume its original shape when the distorting force is removed shows the property of elasticity.

The elastic limit is the smallest stress which produces permanent distortion (plasticity)

Within the limits of perfect elasticity, strain is directly proportional to stress. (Hooke's law)

The ratio stress/strain is different for different solids. This ratio allows the comparis on of the elasticity of different solids. It is called the elastic modulus and is defined by the equation

$$Y = \frac{stress}{strain}$$

LIQUIDS

The properties of liquids which depend on molecular forces, molecular motion or on weight of molecules are:

Diffusion

Cohesion and adhesion : e.g. finger in adhesive resistance = cohesion
glass dipped in water drops = adhesion

Surface tension : The tendency of a liquid surface to contract is called surface tension. Surface tension causes liquid firms to be elastic
Surface tension causes a free liquid to assume a spherical shape (drops) fig. 1

Capillarity : Water does not stand at the same level in connecting tubes of varying diameters.
The elevation or depression of liquids in small diameter or capillary (hairlike) tubes is called capillarity (fig. 2)
Capillarity depends on both adhesion and surface tension.

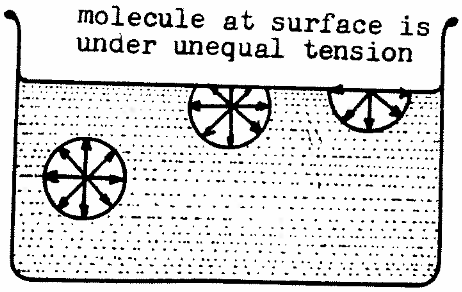
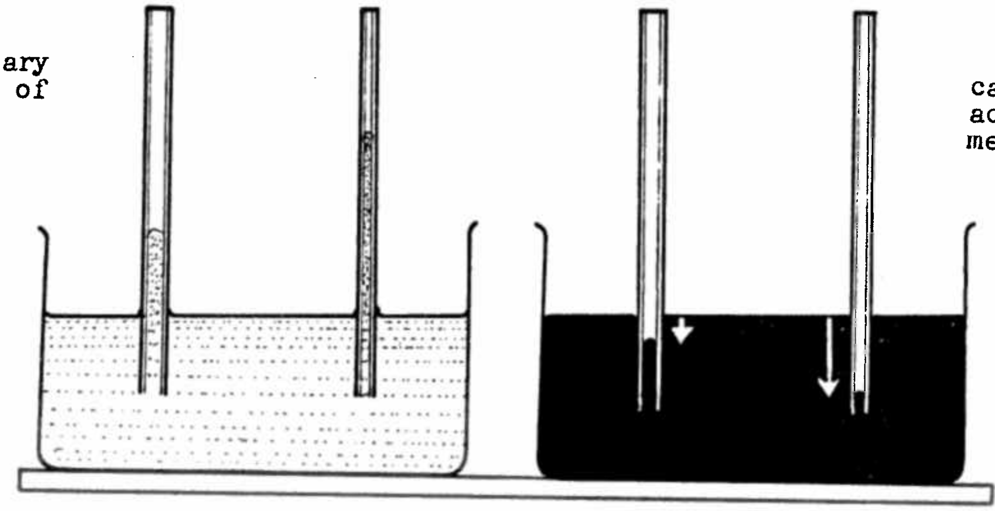


fig. 1

the unbalanced downward force on molecules near the surface of a liquid causes surface tension.

capillary action of water.



capillary action of mercury.

fig. 2

Liquid pressure : Pressure is force applied to a unit of area

$$Pa = 1 \frac{N}{m^2}$$

It is obvious that a liquid exerts a downward force because of its weight, a liquid also exerts a sideward force and an upward force. Thus a liquid exerts force, and therefore pressure, in all directions.

Total force exerted by liquids

Total force is the force acting against the entire area of a particular surface.

A liquid exerts a total force against the entire area of the bottom and sides of a container. Since liquid pressure equals force per unit of area, total force will equal the product of the average pressure on the area by the entire area.

Pressure transmission by liquids

Suppose we put a stopper in one end of a length of iron pipe and then fill the pipe with a liquid. If we now push a second stopper into the open end of the pipe, the first stopper is pushed out, showing that the liquid in the pipe transmits the pressure that was on the second stopper to the first stopper.

Now let us drill several small holes in the pipe and repeat the experiment. As the second stopper is pushed into the pipe, the liquid squirts out through the holes. This shows that the pressure applied to the confined liquid is transmitted throughout the liquid.

Principle of Pascal

Pressure applied anywhere on a confined fluid is transmitted undiminished in every direction. The force thus exerted by the confined fluid acts at right angle to every portion of the surface of the container, and is equal upon equal areas.

The apparatus in fig. 3 is a machine which multiplies force.

The Hydraulic Press

The hydraulic press is an application of Pascal's principle.

In fig. 4, assume that piston A has an area of 1 cm^2 and is loaded with a weight of 1 kg and that piston B has an area of 100 cm^2 and a load of 100 kg. The weight of 1 kg on piston A will just balance the weight of 100 kg on piston B.

In this machine, we must remember that as the force is multiplied, the distance and speed of the load is correspondingly decreased.

Supposed we push piston A down 10 cm, then 10 cm^3 of water will be forced from tube A into B. This 10 cm^3 of water must be spread over an area of 100 cm^2 in B. Therefore it raises the water level and the piston in B

$$\frac{10\ cm^3}{100\ cm^2} = 0.1\ cm$$

Fig. 5 is a simplified diagram of a hydraulic press.

note: On most of the hydraulic machines, the force given by the piston is transmitted to a plate which area is greater than that of the piston, the force exerted by the plate in Pa/cm^2 is not the same as that of the piston. On the other hand, the pressure is given by a manometer in units which are not always corresponding to the actual pressure.

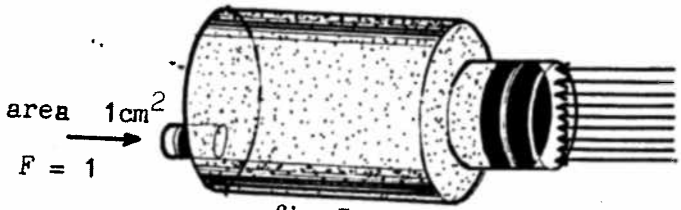


fig.3

A 1 kg weight placed on the small piston can balance a 100 kg weight on the large piston because the large piston has an area 100 times that of the small piston.

area 100 cm²
Force x 100

Principle of Pascal

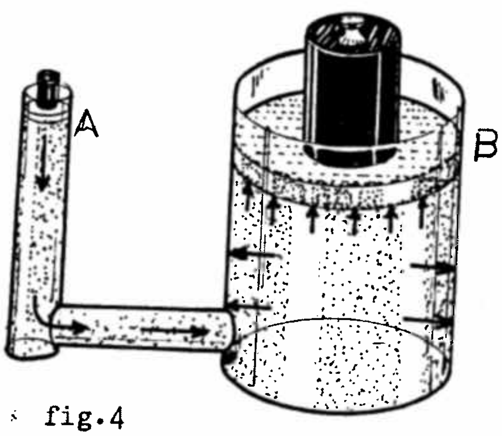


fig.4

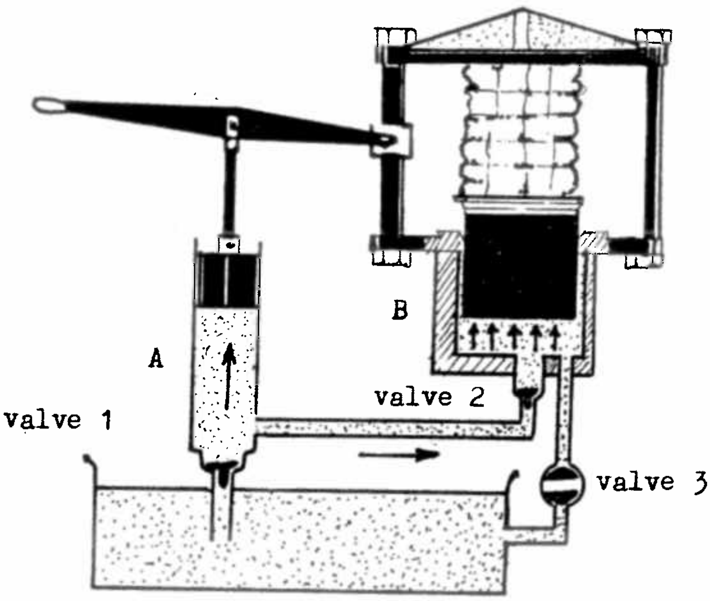


fig.5
HYDRAULIC PRESS

The pressure on the plate expressed per cm^2 is the specific pressure.

$$\text{specific pressure} = \frac{\text{Total pressure}}{\text{area}}$$

If a press has a total pressure of 300 T or 300.10^3 kg
and the size of the plate is 800 x 660 mm

the specific pressure $= \dfrac{300{,}000 \text{ kg}}{5280 \text{ cm}^2} = 57 \text{ kg/cm}^2 = 57.10^3 \dfrac{\text{N}}{\text{cm}^2} = 57.10^3\text{Pa} = 57 \text{ kPa}$

The buoyant force of liquids

Cork and wood float on water, we can swim. This shows that water exerts an upward force on objects placed in it.

Objects denser than water, eventhough they sink readily, appear to loose a part of their weight when submerged.

The upward force which any liquid exerts upon a body placed in it is called the buoyant force.

Principle of Archimedes (287-212 BC)

The buoyant force which a fluid exerts on a body placed in it is equal to the weight of the fluid the body displaces.

Archimedes' principle is applied in the design of ships, pontoon bridges, dry docks and buoys. It is also applied in the measurement of the density of various substances.

Frequently it is helpful to compare the density of one substance with that of another. However, in order to make such comparisons meaningful, a standard is needed.

Water is the standard chosen for comparing the density of solids and liquids. The ratio of the density of a solid or a liquid to the density of water is called its specific gravity

$$\text{specific gravity} = \frac{\text{density of a substance}}{\text{density of water}}$$

The mass density of water is 1 g/cm^3
The mass density of copper is 8.9 g/cm^3 Copper is thus 8.9 times as dense as water and its specific gravity is 8.9

Specific gravity is simply a ratio of comparison, it is therefore a abstract number and has no units.

Measuring Specific Gravity

1. Solids

1.1 solids:denser than water.

If the solid is insoluble, and non absorbent, the difference between its weight in air and its weight in water equals the buoyant force of the water.

The buoyant force will be the difference between the weight in air and the weight in water.

1.2 solids:less dense then water.

As the solid must float, an indirect method, employing a dense sinker is used to find the buoyant force.

The difference between:

- the combined weight of the solid in air and the sinker in water and
- the combined weight of both the solid and the sinker in water,

is the buoyant force of the low-density solid.

example: a sample piece of rubber soling material weighs 2 g
a sinker submerged in water weighs 6 g
the combined weight of the rubber piece and sinker when both are submerged is 1 g

$$\text{sp. gr. of the rubber} = \frac{2\ g}{(2\ g + 6\ g) - 1\ g} = 0.285$$

Measuring the specific gravity of a porous and absorbent substance, like leather, is only possible by an indirect method, we measure then the apparent density.

As sole leather is sold by weight, and utilized by volume, the measurement of the specific gravity could be a good evaluation to compare different leathers. Only the apparent density can be measured by weighing a sample of leather, measuring its volume and giving the ratio weight on volume.

2. Liquids

There are several methods for comparing the weight of a liquid with the weight of an equal volume of water.

We will limit us to the hydrometer method.

The hydrometer is a glass apparatus loaded with a weight in such a way that a scale corresponding to the depth of immersion can be read on it.

0 on the scale corresponds to pure water
10 on the scale corresponds to a solution of 10 parts salt in 90 parts of water.

GASES

Gases expand, exert pressure and diffuse. Like liquids, gases exert a buoyant force.

Gases usually are measured in volume units at stipulated temperature and pressures.

The volume of a dry gas varies inversely with the pressure exerted on it, provided the temperature remains constant.

Air is a mixture of gases and exert pressure, the atmospheric pressure.

Gases and liquids have many properties in common, then term "fluid" is applied to both liquids and gases, and since the behavior of moving liquids is similar to the behavior of moving gases, we treat them together as fluids in motion.

Fluids in motion

The motion of fluids is very complex (waves, tornados)

In a tube whose diameter varies, the motion of water flowing through the tube is smooth and even.

Since the volume of water passing any cross-sectional area of the tube is the same in any given length of time, the water must flow more rapidly through the narrow portion of the tube than through the whole wide portion. (fig. 6)

The smooth flow of a fluid through a tube is called streamline flow

If the speed of the fluid becomes to great, or if changes in the diameter or in the direction of the tube are to abrupt, the fluid does not flow smoothly. The flow is then said to be turbulent.

For the horizontal flow of a fluid through a tube, the sum of the pressure and the kinetic energy per unit volume of the fluid is a constant (Bernoulli's principle). (fig. 7)

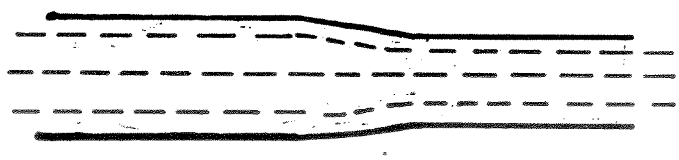


fig. 6

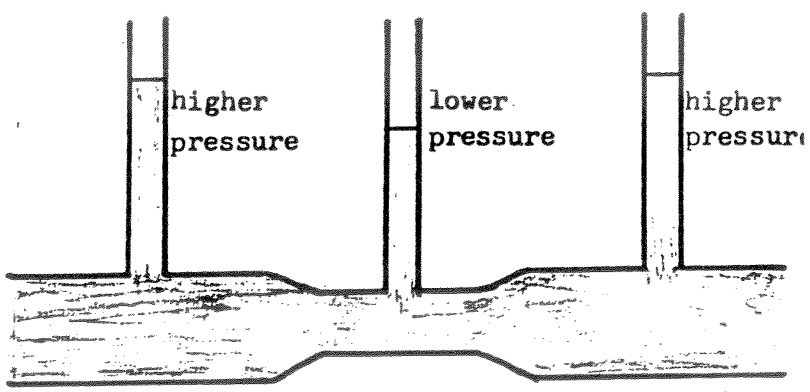


fig. 7

In the wide portions of the tube (fig.7) the speed of the fluid is lower than in the narrow portions. The pressure exerted varies in function of the speed of the fluid. If the speed becomes very high, the pressure may become lower than the atmospheric pressure, there is then aspiration (fig.8).

Applications : vacuum aspirator (fig.9)
spray gun (fig.10)

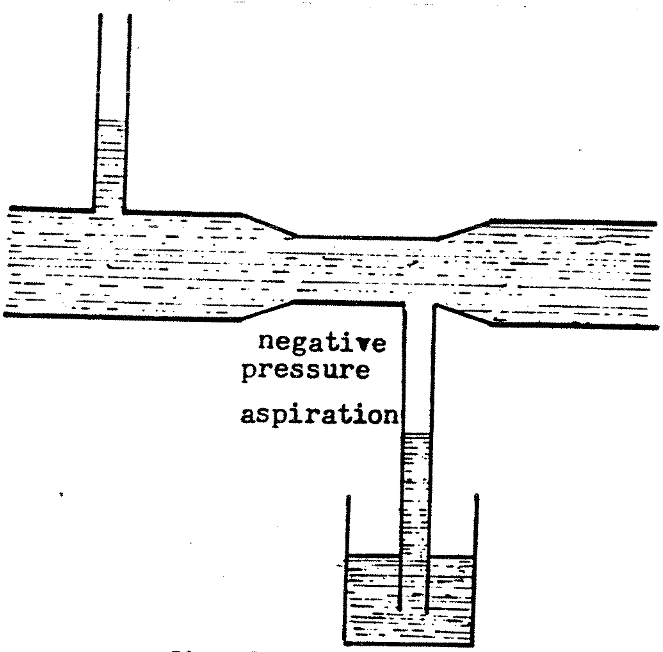


fig. 8

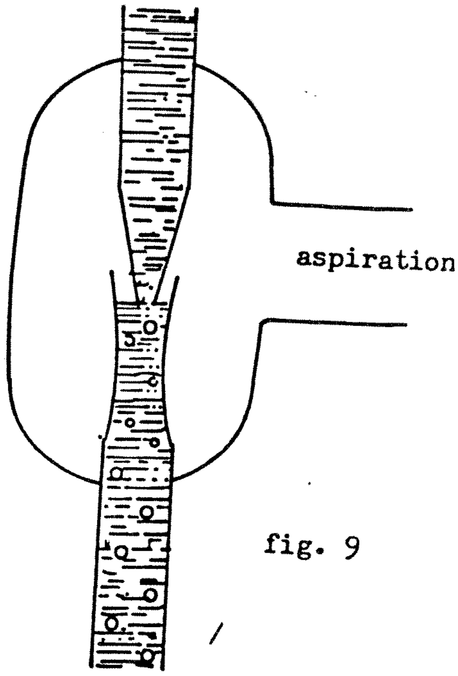


fig. 9

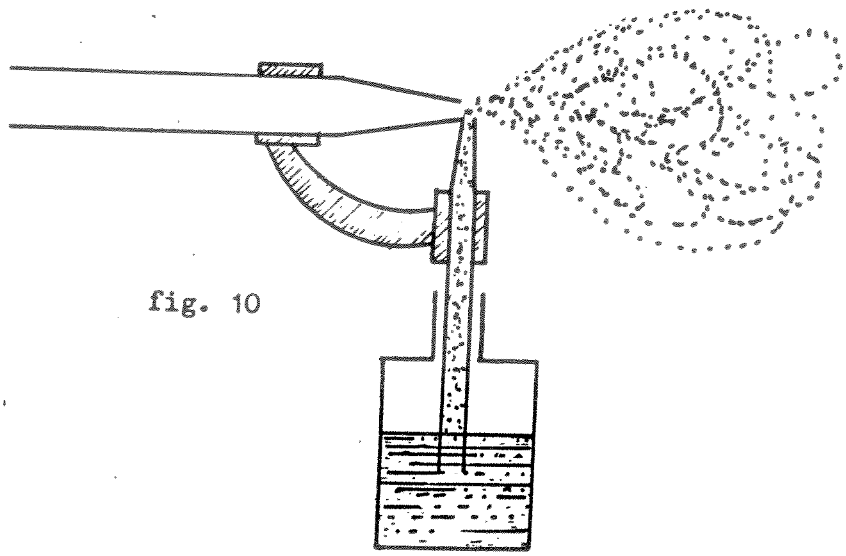


fig. 10

Water Jet Cutting see pg. 51

Fluid friction and viscosity.

Friction opposes the movement of fluid molecules over one another in flowing liquid or gas.

This internal friction of a fluid is viscosity.

Because of viscosity, a force must be exerted to cause one layer of a fluid to slide over another, or to cause one surface to slide over another. (rotative viscosimeters)

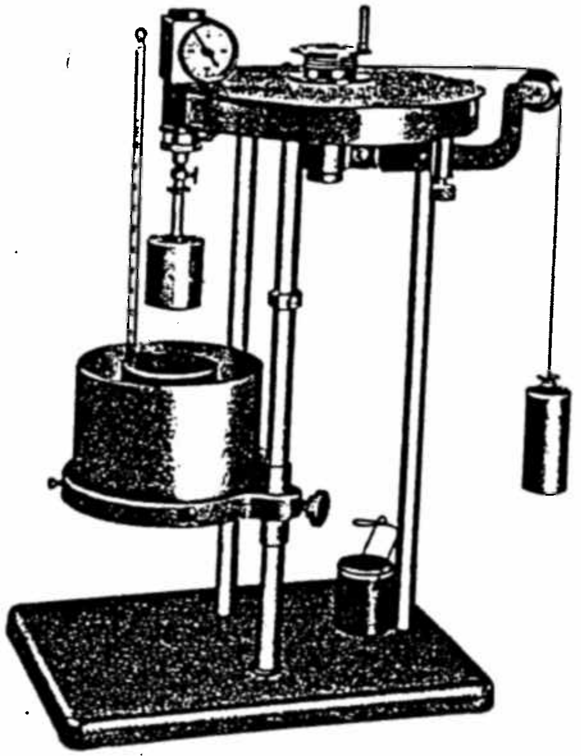
The viscosity of a liquid decreases as the temperature rises because the cohesive force between the molecules of a liquid determines its viscosity.

The S.I. unit for dynamic viscosity is the pascal second Pa.s
The pascal second is equal to the dynamic viscosity of a homogeneous fluid in which, two layers one metre a part, the top layer is moving parallel to the bottom layer at a velocity of 1 m/s and a shearing stress of 1 Pa is required to maintain this motion.

Still in use, namely for adhesives, the centipoise, cP

1 poise = 1 P = 0.1 Pa s
1 centipoise = 1 cP = 0.001 Pa s

To measure viscosity of adhesives, rotational shear type viscosimeters are used, they determine viscosity as a function of time required for a definite number of revolutions of a rotor immersed in a sample, under a constant driving force.



Viscosimeter

VI. HEAT

Heat is a form of energy. (heat from friction, boring or drilling tools)

The most important sources of heat are:

- the sun
- the earth interior (volcanos and geysers)
- chemical action (fuels react with oxygen, food with oxygen)
- mechanical energy (friction)
- electric energy (resistance of a conductor to the passage of current)
- nuclear energy

Heat and temperature are related but are not the same.

The thermal energy of a material is the potential and kinetic energy of its particles which can be evolved as heat.

The quantity of thermal energy possessed by a body determines its temperature.

Heat is thermal energy which is

- being taken up by a material,
- being given up by a material, or
- being transferred from one material to another.

The temperature of a material is a measure of its ability to give up heat to, or absorb heat from other materials.

Temperature may be measured in Kelvin scale, Celsius scale (see SI Units) or Fahrenheit scale.

<u>note</u> : On the Fahrenheit scale, the ice point is 32^{o} C and the steam point is 212^{o} C. The interval between this two fixed points is divided into 180 degrees.

For conversion from Fahrenheit in Celsius:

1. substract 32
2. then multiply by 5
3. then divide by 32

$$50^{o}\ F = \frac{(50 - 32) \cdot 5}{9} = 10^{o}\ C$$

For conversion from Celsius in Fahrenheit:

1. multiply by 9
2. then divide by 5
3. then add 32

$$10^{o}\ C = \frac{10 \cdot 9}{5} + 32 = 50^{o}\ F$$

<u>Expansion</u>

The change in unit length of a solid when its temperature is changed one degree is its coefficient of linear expansion.

The expansion of most liquids is proportional to their temperature increase, but the expansion of water is abnormal. (decreases from 0^{o} to 4^{o})

Gases expand uniformely except at extreme pressures and low temperature.

The measurement of heat

The expansion of mercury in a thermometer provides a convenient and accurate method of measuring temperature.

The measurement of heat is not so simple for there is no instrument that can give directly the amount of thermal energy a body can give out or absorb, therefore quantities of heat are measured by the effect they produce.

The SI unit of measurement of heat is the joule, J

The c g s unit is still in use and is the calorie.

The quantity of heat needed to raise the temperature of one gram of water one degree celsius is one calorie.

The frigorie is the negative calorie.

The heat capacity of a body is the quantity of heat needed to raise its temperature one degree celsius. calorie/C^o

The specific heat capacity, or specific heat, of a material is the ratio of its heat capacity to its mass or weight.

cal / g C^o

Law of heat exchange

The heat given off by hot substances equals the heat received by cold substances.

When a body absorps or gives off heat, there are changes in its state. (application to heat-setting)

VII. WAVE MOTION

1. Energy transfer by waves

We discussed the transfer of energy:

- by bodily motion of masses of material (winds, tides, projectiles)
- by motion of particles (electricity or hear conducted through metals by the motion of electrons)

WAVE MOTION is a third method of energy transfer.

There are two kinds of waves:

- mechanical waves (a disturbance that moves through matter)
- electromagnetic waves (a disturbance that moves through space) In electromagnetic waves there is no motion of matter but motion of an electromagnetic field.

Waves have common characteristics such as speed, phase, frequency, period, wavelength and amplitude. (*)

(*) Speed : Travel's distance of a wave in unit of time.

Frequency : Number of waves passing a given point in unit of time.

Period : The time required for a single wave to pass a given point.

Wavelength : The distance between any particle in a wave and the particle in the next wave which is in phase with it.

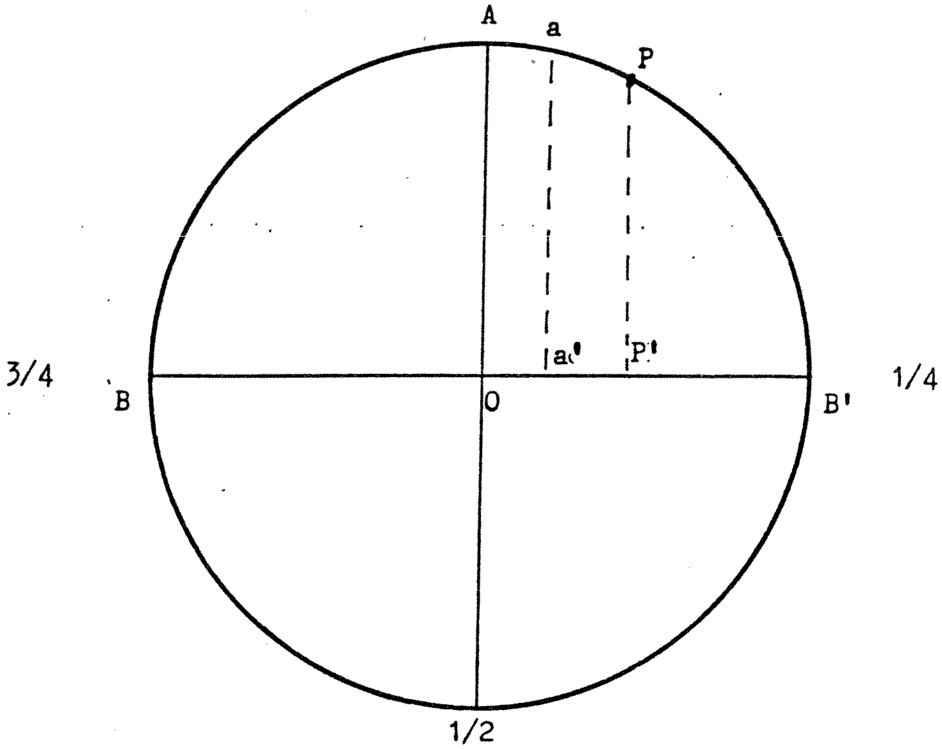
Amplitude : The maximum displacement of the vibrating particles of the medium.

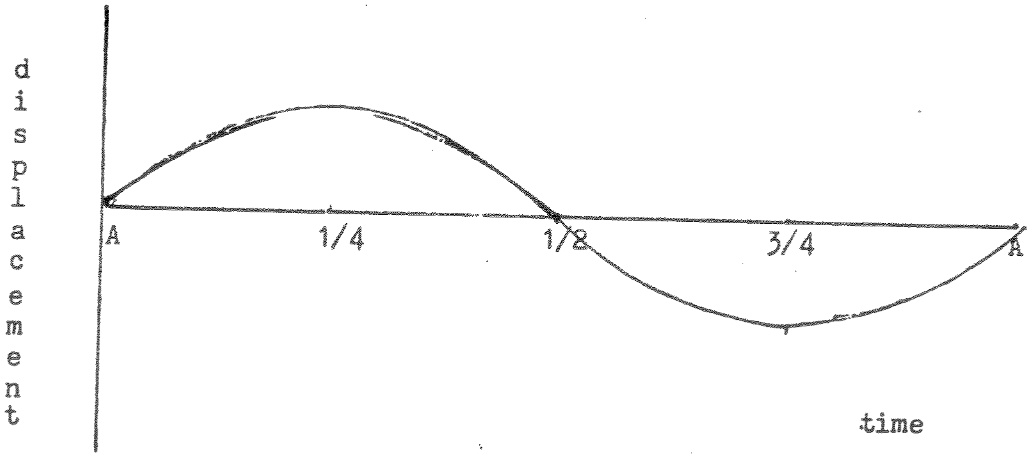
Common properties of waves include:

- rectilinear propagation : movement through an uniform medium in a straight line,
- reflection : turning back at the boundary of the transmitting medium,
- refraction : changing direction on passing from one medium to another of different density,
- interference : combining the disturbances of two wave motions,
- diffraction : bending of a wave around an obstacle in its path.

A wave may also be a graphic representation of a simple harmonic motion. For example, a point P moving with uniform speed in a circular path around point O. The perpendicular projection of point P on the diameter BOB' is point P' moving on the diameter BOB'. When point P is at A, P' is at the position O. When P is at a, P' is at a' and so on. As point P makes a complete revolution of the reference circle, point P' moves along the diameter BOB'. The displacement of P' describes a complete vibration in simple harmonic motion.

If we put on a graph in coordinate y the displacements of point P' and in coordinate x the times, we become a sinusoide showing all the characteristics of a wave.


A
a
P
a'
P'
3/4
B
O
B'
1/4
1/2


displacement
A
1/4
1/2
3/4
A
time

2. Sound Waves

Sound is a series of disturbances in matter to which the ear is sensitive.

The term also applies to similar disturbances above and below the normal range of hearing.

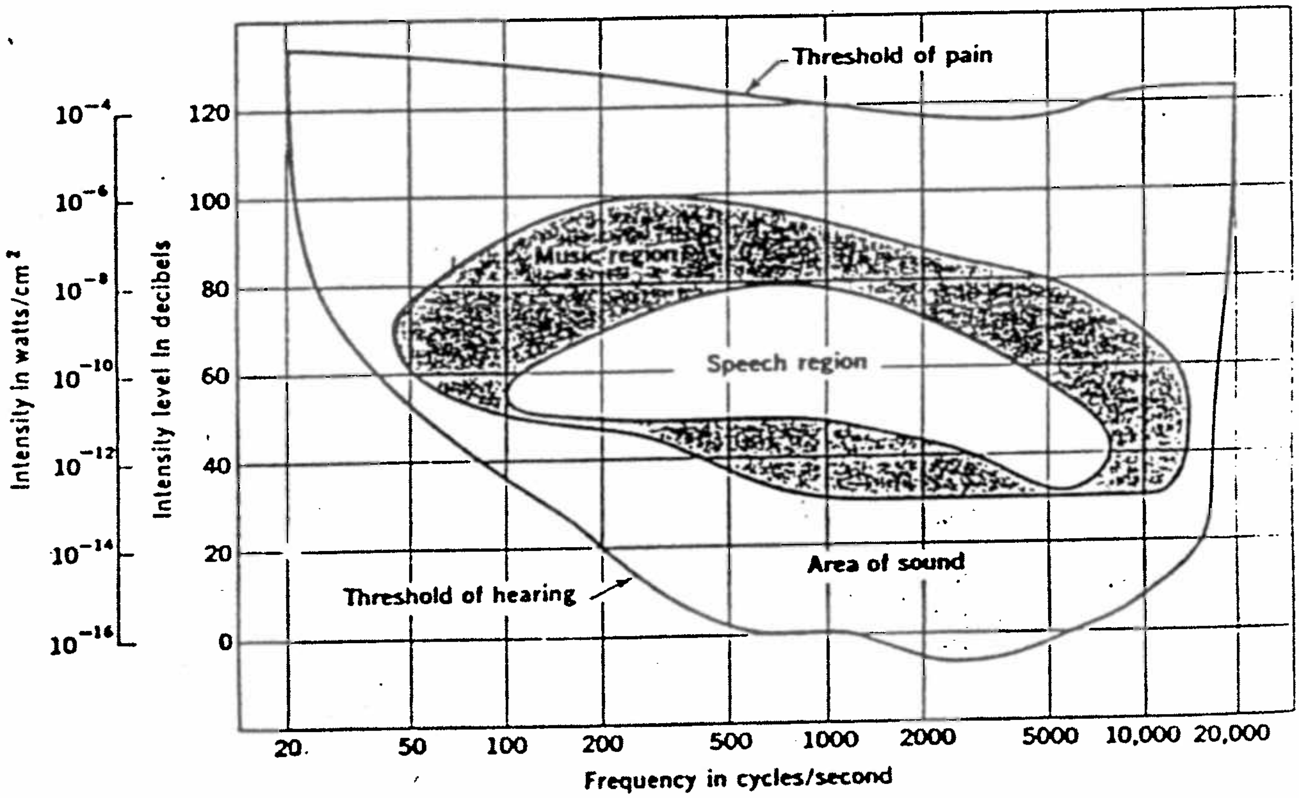
Sounds are produced by vibrating matter and require an elastic material medium for transmission. (low transmission at high altitudes because of lower density of the air, no transmission in vacuum). Liquids are better transmitters of sound than gases. Solids are better transmitters of sound than either liquids or gases.

Sounds differ from each other in several fundamental properties, namely two physical properties : intensity and frequency. The effects of those two properties on the ear are called : loudness and pitch.

The unit of sound intensity is the decibel. The decibel scale (A. Graham Bell) goes from 0, threshold of hearing to 120, threshold of pain.

The frequency is expressed in cycles/second or in Herz/second.

The range of audibility of the human ear.



The general frequency limits for the audio range to be between 20 and 20,000 cycles/sec.

Vibrations below 20 cycles/sec are in the infrasonic range (application in drilling of deep oil wells) microwave oven see note on page 39

Sound waves above about 20,000 cycles/sec are in the ultrasonic range. There are many application of ultrasonic waves : automatic control of garage doors, detection of flaws in metals or tyres, tenderization of frozen food, surgery, mixing of liquids, etc.)

Ultrasonic waves are produced by applying a high frequency alternating voltage to opposite faces of a quartz cristal, causing the crystal to vibrate. Frequencies as high as 10 billion cycles/sec have been attained.

3. Ultrasonic or High Frequency Waves

When ultrasonic or high frequency waves (sometimes called radio waves) are going through a material, the molecules of that material start to move, an electric field is created and the movement of the molecules generates heat. That heat can be used for many industrial application such as : hardening, welding or soldering, flow moulding, embossing, drying, sterilization, etc.

The high frequency waves are a current flow through the material which becomes a conductor. The flow will depend from the resistance of the material, its capacitance and from the frequency.

If the material is a good conductor, the flow of the current is very fast. The energy of the moving electrons is impacted to the molecules. In a very short time, high temperatures, up to 815°C can be reached.

Application : hardening of sewing and knitting machines needles by treatment under a flow of 140 megacycles/second during 2 to 3 seconds followed by a quick cooling in with nitrogen gas.

If the material is a poor conductor, movement is also imparted to the molecules and heat created, but the gradient of raise of temperature is slower so that it can be kept in the range of melting or flowing temperatures of the materials.

The applications are numerous, namely :

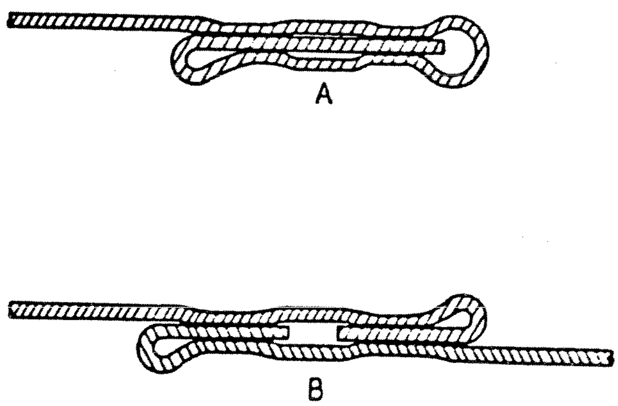
- embossing of coated fabrics or poromerics,
- welding of man made linings,
- folding of synthetic upper materials,
- junction of leather or synthetic materials by interlining of hot melts adhesives,
- drying and conditioning of leather, and
- recently : printing and coloring of leather by transfer of a colored film from a silicone pre-printed paper. This allows tanners or even footwear producers to reduce their stocks of finished leather.

  The leathers are dyed in a standard pale violet shade, just to cover the green-blueish color of chrome tanned leather, and stored as such.

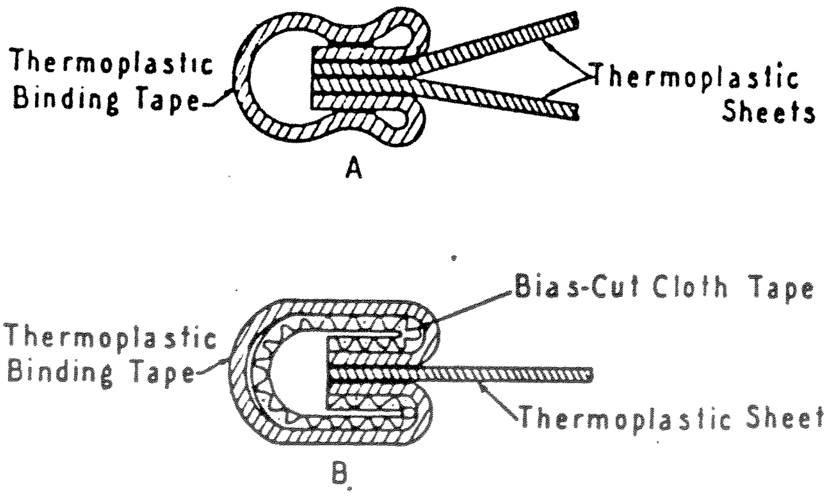
  On request, a finish preparation in any color, shade or type. - including metallic shades, patent, wet look, etc. - is prepared and sprayed on silicone paper. The finish is then transferred by HF to the quantity of leather requested for the production.

High Frequency electrodes can be adapted to conventional sewing machines by replacing the needle by a hallmark to make stitching imitations or by a wheel to make binding, folding etc.

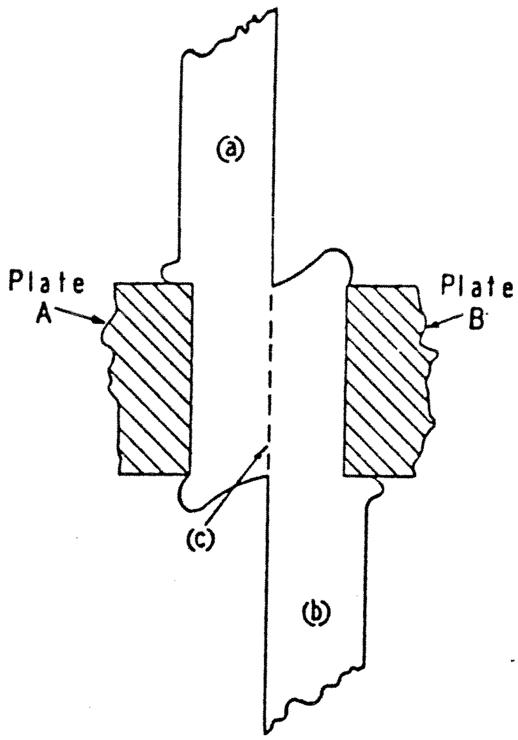
One of the problems in HF devices used in footwear production is the overheating of the electrodes which can cause extrusion of the finish of man made materials due to softening of the surface.



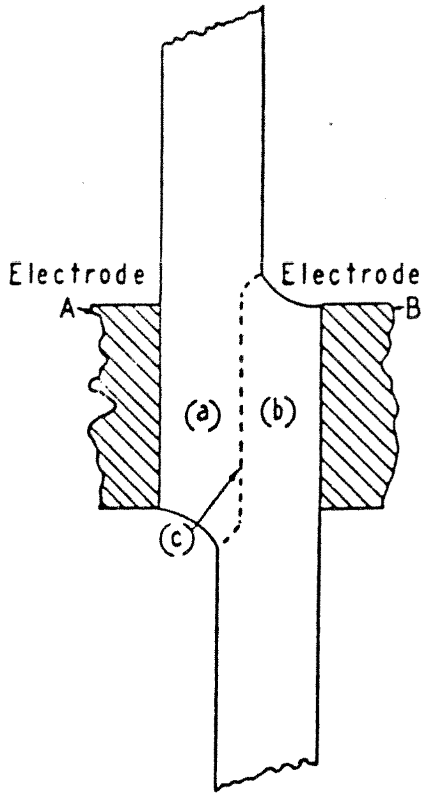
.. Cross-section of bonds made on radio-frequency sewing machine ipped with a double or grooved electrode-wheel. A. Wide hem made ı hemming attachment. B. Imitation strap seam made with folding attachment.



. Cross-section of bindings applied to thermoplastic sheeting. Conventional sewing machine attachments were used on the radio-frequency sewing machine.



Application of heated plates A and B cause extrusion due to excessive softening at the surface.



Cool electrodes A and B prevent overheating of the surface. Contiguous surface (c) is softened most by radio-frequency heating.

Notes on MICRO-WAVES ovens

Ultra-short waves are produced in a device called "magnetron". Those waves disperse randomly at about 2,450,000 times per second and are used to heat or cook anything containing molecules very quickly.

Electricity is converted by the magnetron tube into microwaves energy, which is "broadcast" into a closed oven.

The magnetron tube is a vacuum tube where the electron flow is under control of a magnetic field external to the tube.

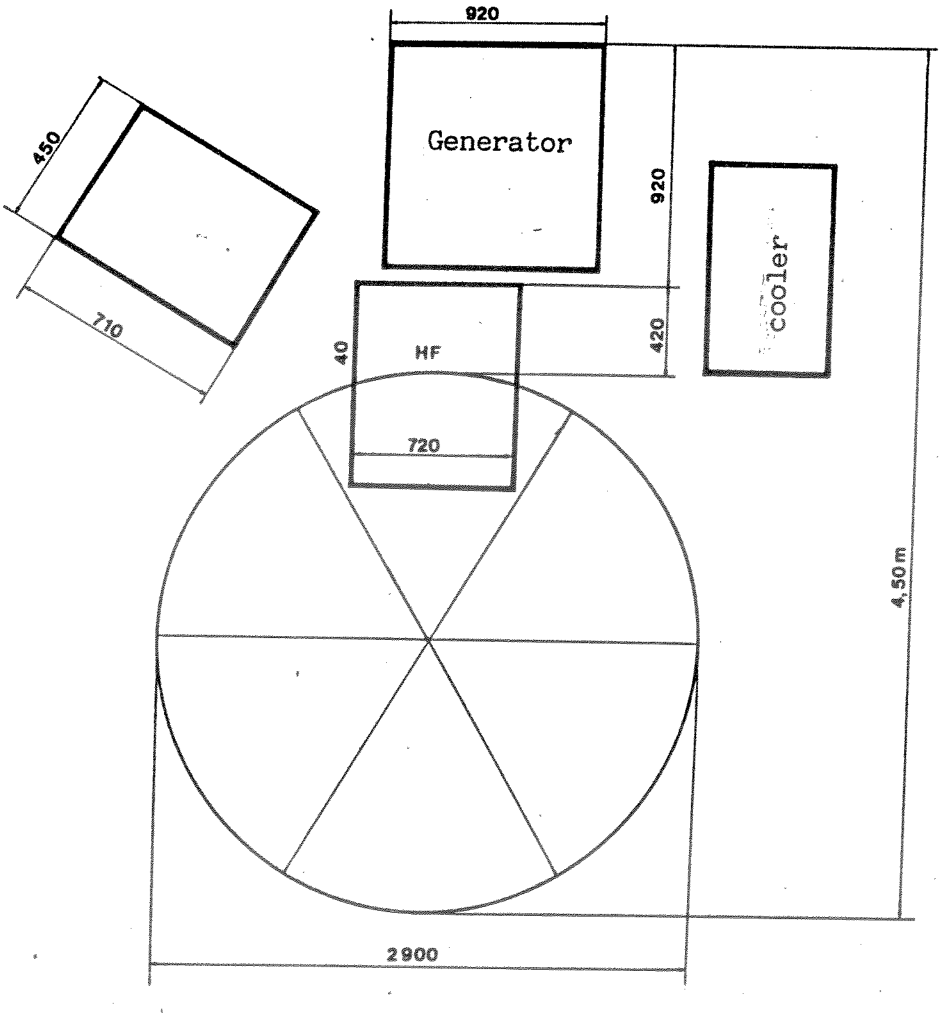
This is the same device used by radio stations to produce radio waves of short frequencies.

This short waves agitate the molecules in the food about 2.5 billion times per second. It is the friction between the molecules that produces the heat.

Microwaves will not pass through metal, so that the waves will not come out of the oven and only the food placed in metal dishes will be heated.

Microwaves will pass through glass, paper, wax paper, thin aluminum foils, most plastics and ceramics.

xxxxxxxxxxxxxxxxxxxx



H.F.
Carrousel

eumatic consumption	7 m³/H à 6 bars	
ctrical consumption Carrousel motor		1/3 CV
iller motor	3 CV	
nerator 30	45 KW	
e of the plates	450 x 600 mm	
ight	net	gross
rousel	2290 kg	3550 kg
ntrol unit and tubes	466 kg	700 kg
face on the ground	4500 x 2900	

VIII. LIGHT

1. Light Waves

Light is the aspect of radiant energy of which an observer is aware through the visual sense.

Matter is not required for the propagation of light.

Propagation of light is complex and goes partially through particles (Quantum theory of Max Planck) and partially through waves (Huygens theory). Light has a dual character.

2. Sources of Light

There are two general sources of light :

- Natural. Nearly all the natural light we receive comes from the sun (moon reflection, stars to distant)
- Artificial. There are several ways of producing artificial light : heating of a material (incandescent)
  bombing of molecules of a gas by electrons (neon)
  action of U.V. on phosphorus (fluorescent)
  Chemical reactions (Firefly)

3. Luminous and illuminated objects

An object which gives off light because of the energy of its oscillating particles is said to be <u>luminous</u> (sun, stars, platinum wire)

Light may be reflected from the surfaces of objects.

An object that is seen because of the light reflected from it is said to be illuminated (moon)

Some of the light reaching the surface of a substance is reflected (mirror) some is absorbed and some is transmitted.

Dark-colored objects absorb light, black ones absorb nearly all the light it receives.

Air, glass, water transmit light readily and are said to be transparent, other substances (frosted electric lamp, parchment) transmit light but scatter or diffuse it, these are translucent substances.

Opaque substances do not transmit light at all.

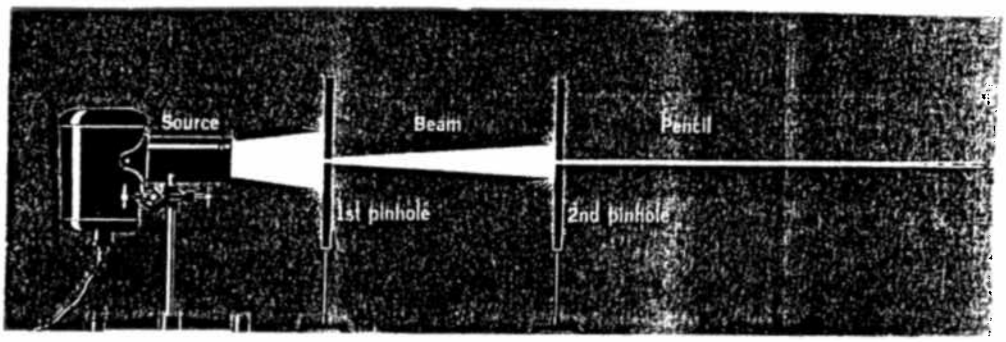
4. Travel of light

From a luminous point-source, light waves travel outwards in all direction.

If the medium through which they pass is of the same nature throughout (homogenous), light waves travel in straight lines.

A single line of light from a luminous point is called a ray, several parallel rays form a beam of light,
when several rays of light comes from a point, they are called a diverging pencil,
While rays proceeding toward a point form a converging pencil

Application in footwear : laser cutting



The formation of beams and pencils of light.

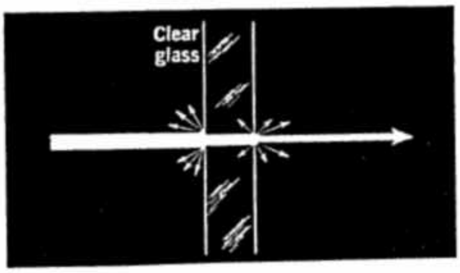
5. Reflection of light

Light waves traveling through air and arriving at a boundary, such as glass, are partly reflected.

The remaining light enters the glass and is :

- partially absorbed
- partially transmitted

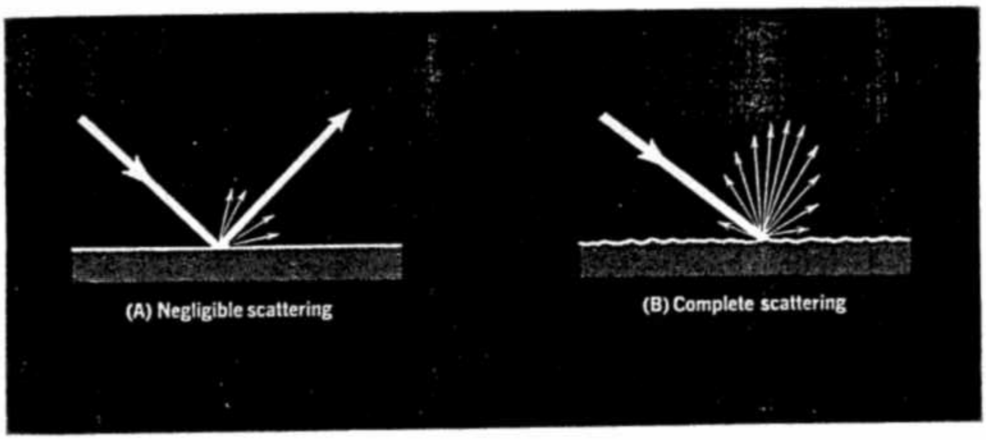
The transmission of light through a glass plate.



The amount of light an object reflects depends:

- on the kind of material it is made of,
- the smoothness of its surface, and
- the angle at which the light strikes its surface

. Reflecting surfaces vary in the extent in which reflected rays are scattered.



Materials differ widely in their reflection and in the extent to which the reflected rays are scattered.

Materials with high reflection will be glossy. Patent leather through its topcoat has a high reflection

Black suede split has a low reflection and a high scattering.

Spraying black suede shoes with a substance (e.g. petroleum emulsion) giving some reflection will improve the appearance of the suede.

6. Refraction of light

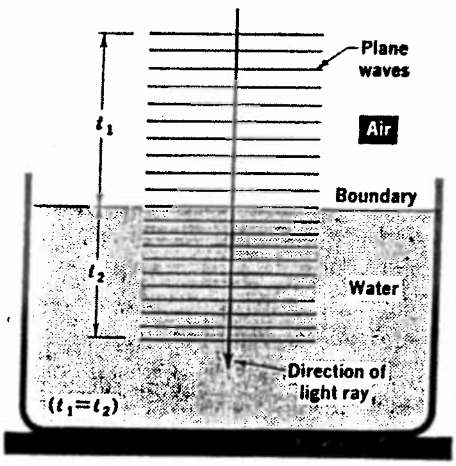
When light transmitted through air is incident on the surface of a body of water, some of the light is reflected at the boundary between the air and the water and some is absorbed by the water.

However, because the water is transparent, most of the light is transmitted through it.

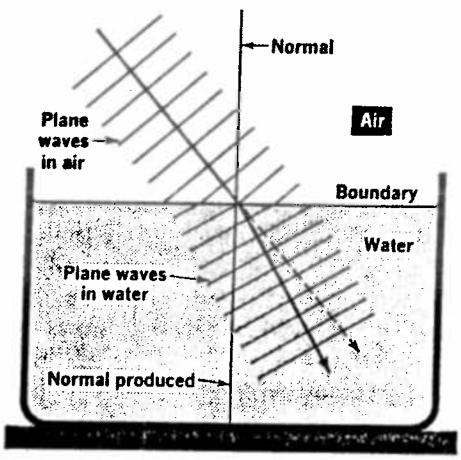
Since water has a higher optical density (*) than air, the speed of light is reduced as it enters the water.

A ray of light that enters the surface of the water at an oblique angle changes direction abruptly due to the change in speed.

. A wave-front diagram illustrating the difference in the speed of light in air and water.



. . A wave-front diagram illustrating the refraction of light at the air and water boundary.



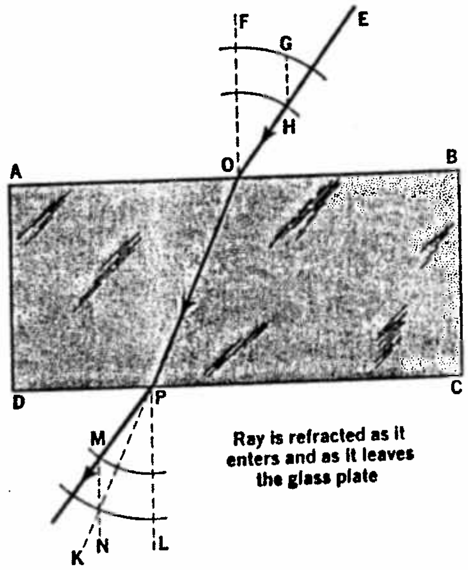
(*) Optical density is a property of a transparent material which is a measure of the speed of light through the material.

This bending of a light ray is called REFRACTION.

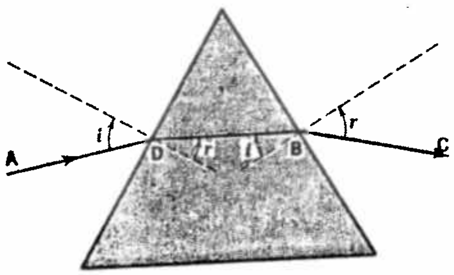
Refraction is the bending of light rays as they pass obliquely from one medium into another of different optical density.

When a ray of light passes through a glass plate, it is refracted as it enters and as it leaves the glass plate.

The path of a light ray passing through a prism is refracted as it enters and as it leaves the prism.



An illustration of the method of tracing a light ray through a glass plate.



The path of a light ray passing through a prism.

7. Invisible Radiation

7.1 Infra-red and ultra-violet

The radiations of the light spectrum have also calorific and chemical properties.

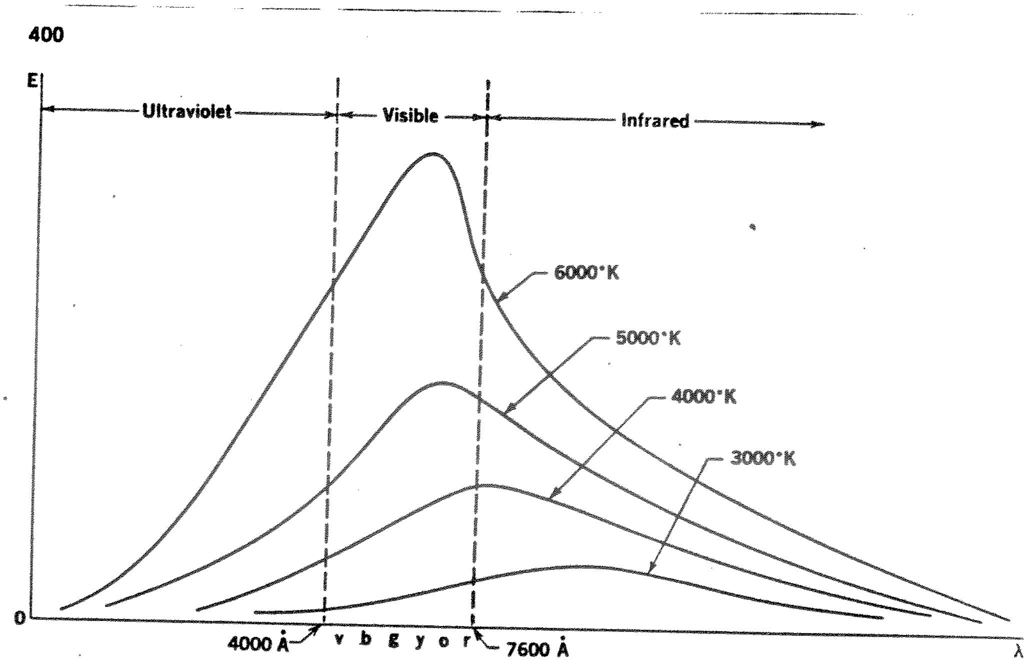
The infra-red radiations are just beyond the range of human visibility and have radiant energy.

Applications : heating and reactivation of adhesive films.

The ultra-violet radiations are just below the range of human visibility and have chemical properties (actinic reactions)

Applications : germicides, photochemical reactions (chlorophile) fluorescent effects.

Most of the yellowing fading of white leathers are due to a chemical oxydation of some substances through the ultra-violet radiations.



Distribution of radiant energy from an ideal radiator.

7.2 The electromagnetic spectrum

Today, the electromagnetic spectrum is known to consist of a tremendous range of radiation frequencies from about 10 to more than 10^{25} cycles per second.

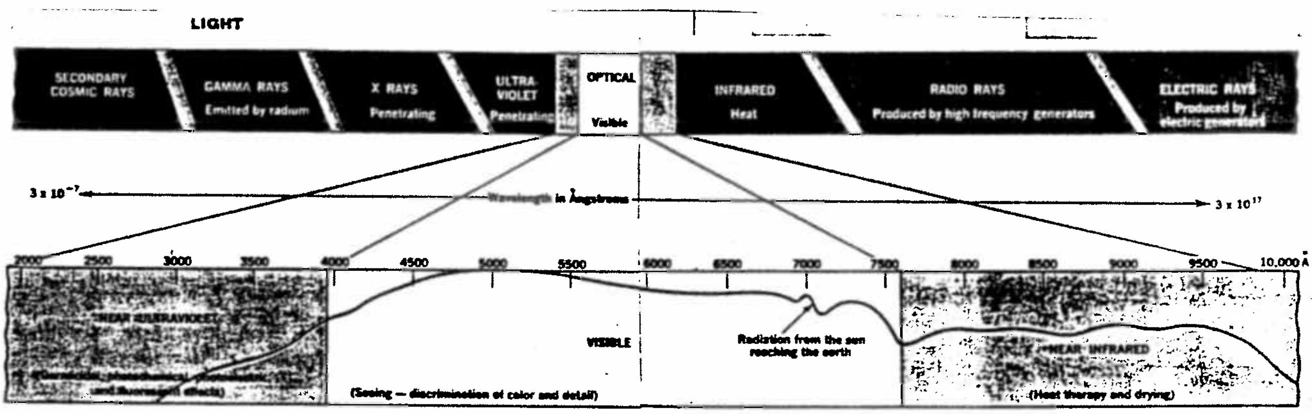
Since all electromagnetic radiations travel in free space with a speed of 3×10^{8} meter per second, the range of wave lengths is from about 3×10^{7} meters in the low frequency region to less than 3×10^{-17} meters in the high-frequency region.

In Ångstroms (Å), the range is from 3×10^{17} Å to 3×10^{-17} Å

In SI units, millimicrons (one micron equals 10^{-6} meter) the range wavelengths extends from 3×10^{16} m to 3×10^{-8} m.

The electromagnetic spectrum may be divided into eight major regions depending on the general characters of the radiations :

(1) electric waves
(2) radiowaves
(3) infrared
(4) optical
(5) ultraviolet
(6) X-rays
(7) gamma rays
(8) secondary cosmic rays



The electromagnetic spectrum.

Electromagnetic energy can be detected and measured by physical means only when it is intercepted by matter and changed into thermal, electric, mechanical or chemical energy.

The optical spectrum includes those radiations, commonly called LIGHT, that can be detected visually. They range from 7600 A to 400 A

Accordingly, light may be defined as the aspect of radiant energy of which a human observer is aware through the visual sense.

The optical spectrum extends into the near infrared and into the near ultraviolet. These radiations, although our eyes cannot see them, can be detected by means of photographic film.

8. LASER

8.1 Principle

A luminous emission having all its particles (photons) vibrating at the same frequency and being in the same phase (coherent) is created in a liquid, gaseous or solid medium.

All the light waves of that emission are orientated and concentrated in the same direction. Through a lens system the light pencil transports a high amount of energy (3kW/cm2 for a 1 kW laser in CO2 with a focus of 0.1 mm)

When a material absorbs that energy its molecular structure is destroyed and goes from solid to gaseous state (sublimation).

By moving the focus contact point it is possible to cut a material.

To produce laser radiations, one needs

1. a source of energy such as electricity, light, or another laser.

2. an active medium in which the radiation is produced. The atoms of the active medium (plasma) will absorb the energy and become a kind of storeroom.

   When saturated, the atoms will give up the excess of energy.

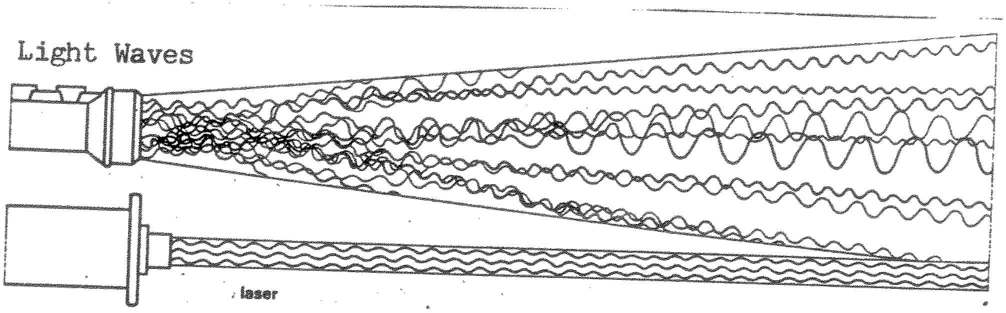
   The plasma can be : a ruby (red laser)
   a liquid (some dyestuff solutions)
   crystals (semi-conductors)
   a gas (CO_2 helium, neon)

   Most of the industrial lasers have CO_2 as plasma, which gives an invisible radiation.

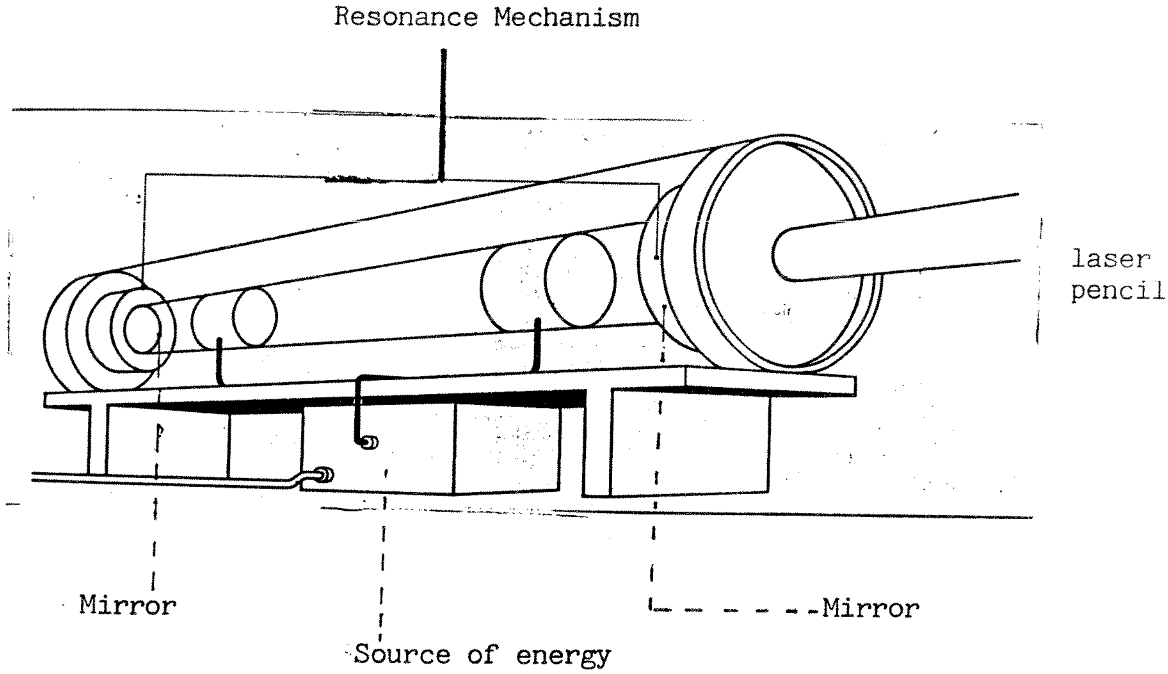
3. a resonance mechanism, or a system of mirrors to increase the intensity of the radiation produced in the plasma.

The produced laser pencil is :

- monochromatic
- directional
- coherent
- intense



GAS LASER



8.2 Applications

There are many applications of laser : welding, surgey, reading of codes and video-cassettes, holography, weapons, guiding of missiles, nuclear industry (fusion of isotopes of H) and cutting.

Metals, plastics, rubber, paper, leather, ceramics and even diamond can be cut by laser.

Leather can be cut because there is no burning but sublimation. To high water or fat content can bring some trouble.

The cutting is very accurate and thin, but with some materials the cutting edges are not straight. To avoid this, a stream of gas is injected in the laser radiation : oxygen during the cutting of metals and alloys; helium or argon during the cutting of leather, plastics or paper.

9. WATER-JET

9.1 Principle

Water is brought at a very high pressure (2,000 to 4,000 bars 20,000 - 40,000 MPa) through a very thin pipe (0.2 mm). The flow of the liquid is at a very high speed (1,000 to 2,000 km/h) allowing to have a coherent jet.

9.2 Application

The energy of the jet is used to cut a material mechanically (not thermically like in the laser) just like a saw where each of the teeth should be a drop of water.

Laser and water-jet cutting are applicable in footwear industry provided the rate of production is high enough and standardized.

Both techniques require a computer (CAO) and a X and Y table. For humid or fatty leather, there is a risk of staining during laser cutting. Some pigments or dyestuffs can show color fading.

Unlike other man-made materials, leather cannot be cut in multilayers because of wetting of the pieces at the bottom of the pile.

Laser and water-jet cutting have the advantages of :

- high productivity and output,
- saving of material (cutting width 0.1 mm),
- elimination of cutting dies, which may be eventually replaced by plexiglass templets.

There are also possibilities of grading with laser. (LECTRA System)

IX. COLOR

A. Dispersion of Light

1. Dispersion by a prism

Sunlight is composed of a polychromatic light which undergoes dispersion when refracted by a prism. This band of colors is called a solar spectrum.

White light of an electric arc will undergo the same dispersion when refracted by a prism.

Six distinct elementary colors are recognized in dispersed white light : red, orange, yellow, green, blue and violet.

Light consisting of several colors is called polychromatic light.

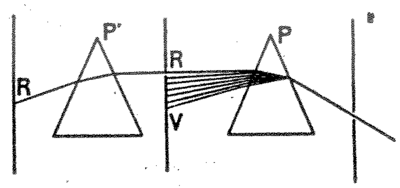
Light consisting of only one color is called monochromatic light.

The transition from one color to the other is gradual, and the elementary colors cannot be further decomposed.

The superposition of elementary colors gives back white light (synthesis of white light)

Complementary colors : any two colors which combine to form white light are said to be complementary.

Newton admitted that white light is composed of monochromatic lights or radiations, their refraction index growing uniformily from red to violet.

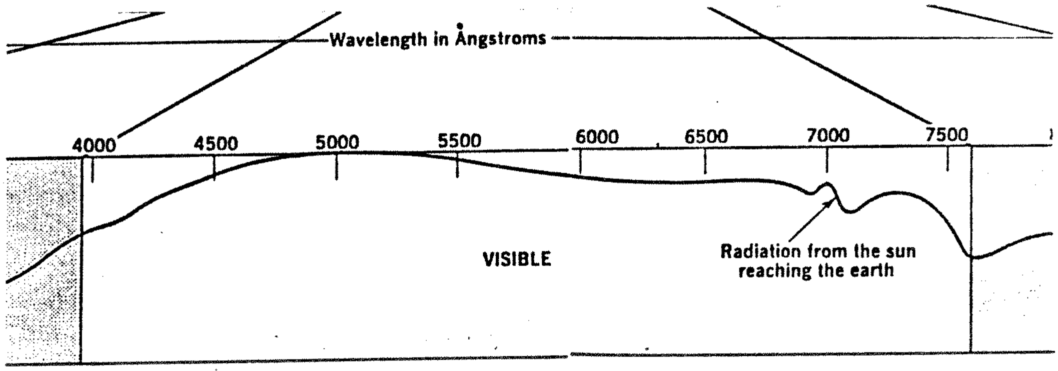


2. Color of light

Color is a property of light that depends on the wavelength of the radiation which reaches the eye.

The energy from a source of polychromatic light is distributed over a range of frequencies that may extend through the entire visible spectrum.

The wavelength of the light at the upper limit of visibility (7000 A) is about twice as great as the wavelength of the light at the lower limit of visibility (4000 A)



3. Color of objects

3.1 By diffusion

The color of an opaque object depends upon the kind of light which it reflects to the eye.

If an object reflects all the colors it receives, we say it is <u>white</u>.

We call an object black if it absorbs all the light rays that fall upon it.

An object is called red if it absorbs all other colors and reflects only red light.

A blue cloth appears black in the red portion of the spectrum because there is no blue light there for it to reflect, and it absorbs all other colors.

For the same reason, a red cloth appears black in the blue portion of the spectrum.

3.2 By transmission

The color of an opaque object also depends on the color of the light incident upon it.

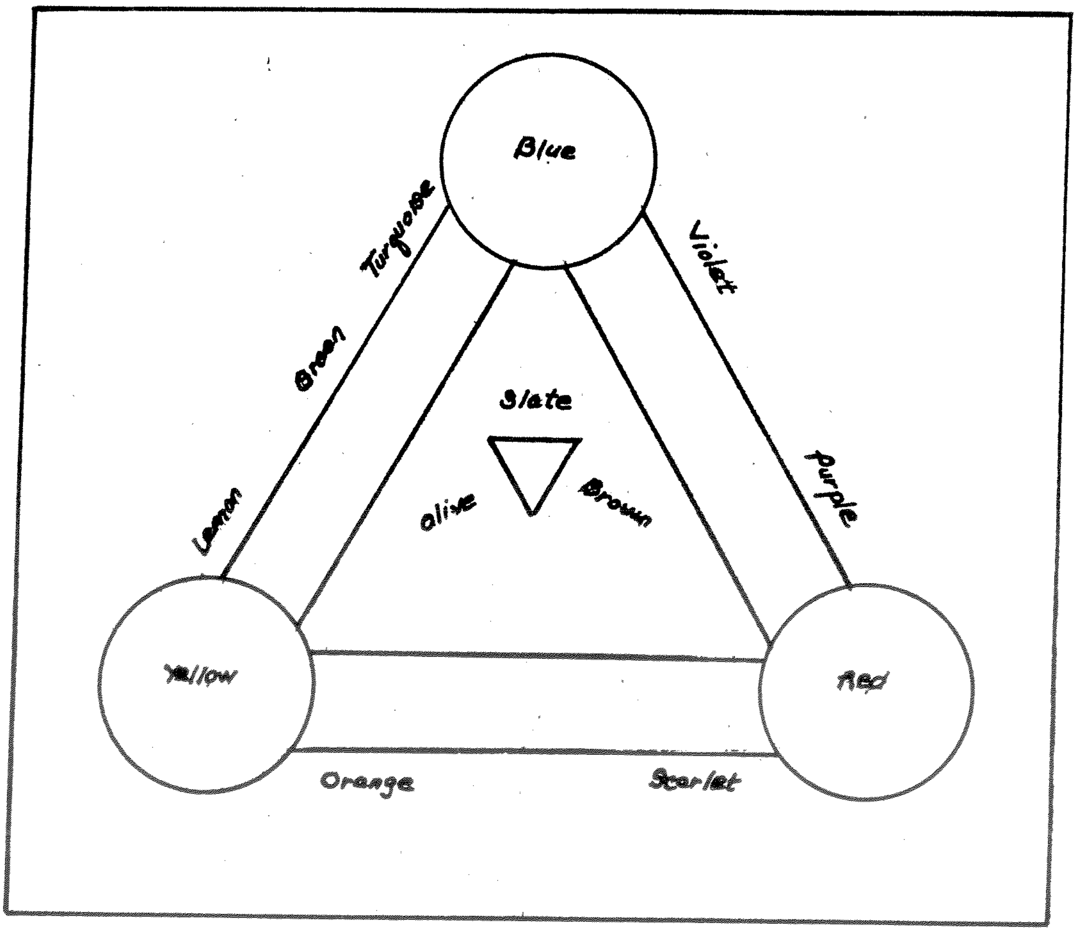
Ordinary window glass, which transmits all colors, is said to be colorless. Red glass absorbs all colors except red, which it transmit.

B. Mixing of Colors

In principle all shades can be obtained starting from the fundamental colors.

This is applied in dyeing textiles under the name of "trichromy".

As leather is not as homogeneous as textile, "trichromy" is not applicable as such to leather dyeing, but the chromatic triangle can give some informations.



From the chromatic triangle it can be seen that, for example, a brown can be obtained by mixing :

- red, blue and yellow, or
- red and green, or
- red and black, or better
- red and gray

A brown could also be realized by mixing orange and bordeau or violet. Red and olive can also give brown.

In practice, it must be remembered that it is easier to go from yellow to red, from yellow to blue and from red to violet then the opposite.

For example, to obtain a dark brown, it is better to start with a yellowish brown and to add bordeau to go to the red then starting from a redish brown to shade it with yellow or orange.

Mixing of colors should never be realized with more than three dyes.

For pigment finishes mixing of colors is different from that of dyestuffs. (see Tannery course : difference between dyes and pigments). Usually, one starts from one pigment to which one or two others are added only to change the shade. There are two main types of pigments : opaque pigments and transparent pigments.

Examples of pigment formulations

	opaque	transparent
BEGONIA (red)	75 parts orange	60 p. red
	25 parts red	30 p. yellow
		10 p. darkbrown
HAVANA	77 parts darkbrown	50 p. yellow
	15 parts lemon	30 red violet
	8 parts black	20 saphire
ROYAL (dark blue)	88 parts turguoise	88 turquoise
	6 parts white	6 white
	6 parts black	6 black
CARRARA (beige)	96 parts white	not applicable
	2 parts caramel	
	1 part black	

X. HYGROMETRY

1. DEFINITIONS

1.1. Water vapour

Air always contains a certain amount of water vapor.
Air has the property of trying to be saturated with water vapour.

Evaporation of water from oceans, seas, rivers (1.5 $kg/m^2/24h$), perspiration of plants, trees, etc., burning of hydrogenated substances, breathing of human and animals give to the air the required amount of water vapor.

Presence of water vapor in the air can be observed in the wetting and dissolving of hygroscopic substances.

1.2. Absolute humidity

The amount of water vapor in the air can be measured and is expressed as absolute humidity.

The absolute humidity is equals to the weight of water vapour carried by one kg of dry air.

1.3 Saturation humidity

When the pressure of water vapor in the air at a given temperature is equals to the vapor pressure of water at the same temperature, the air is saturated and the absolute humidity is designated as the saturation humidity. The saturation temperature varies with the temperature.

1.4. Percentage Relative Humidity.

The amount of water vapour in the air is variable and saturation is only reached in given conditions.

The percentage relative humidity (RH) is defined as the partial pressure of water vapor in the air divided by the vapor pressure of water at the given temperature.

$$RH = \frac{P}{Pw}$$

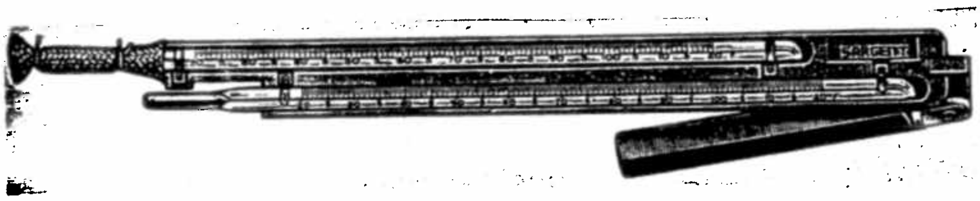
1.5. Dew Point or saturation temperature is the temperature at which a given mixture of water vapor and air is saturated.

1.6. Psychrometer or double bulb thermometer (Hygrometer)

The double bulb thermometer is convenient to measure the relative humidity in the air.

One of the two thermometer has its bulb covered with a wet cloth and will therefore give a reading of temperature in 100% RH. The other thermometer gives the actual temperature.

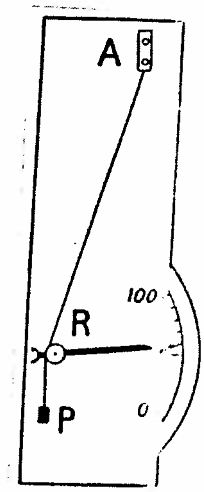
The difference between the wet and dry bulb thermometers gives the depression value. The percentage relative humidity can be read from a chart.



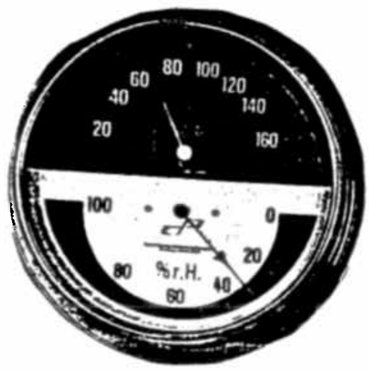
1.7. Hair Hygrometer

One of the ends of a degreased human hair is fixed in a clamp (A) The other end goes on a small pulley (R) and is stretched with a small weight (P) or a very sensitive spring.

As the hair is hygroscopic, it will shrink or elongate according to the humidity in the atmosphere. The changes in length of the hair will move the pulley and the dial fixed on it. Hair hygrometers are first calibrated in a dry atmosphere of 0 % R.H. and then in 100 % R.H. to give the zero and one hundred points in a scale.



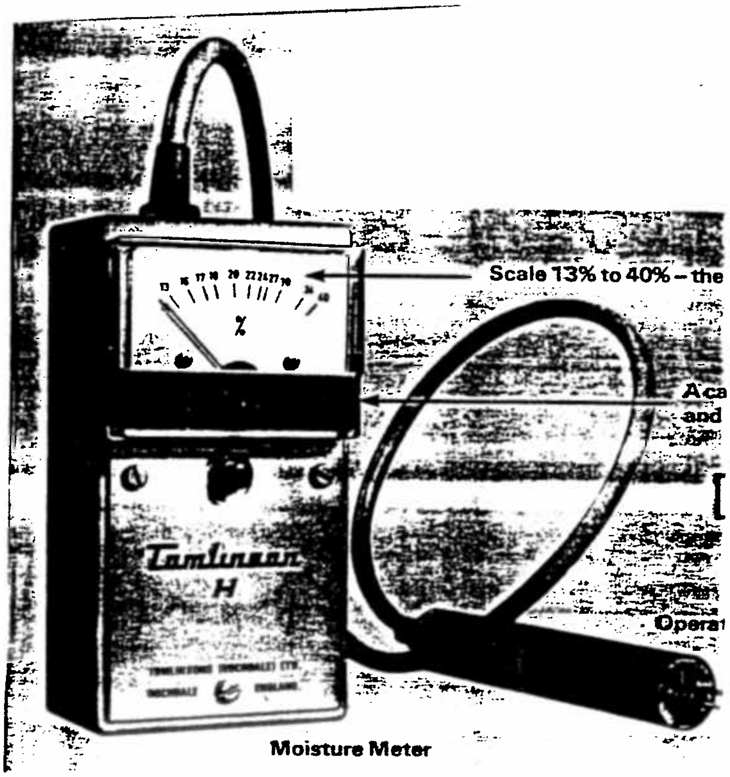
Hair hygrometers need to be recalibrated periodically.



1.8. Conductivity Hygrometers

The presence of humidity in a material can be measured through conductivity. Conductivity hygrometers have two electrodes which are put in contact with the material, the resistance in the electric circuit is recorded as percent of humidity.

These apparatus have a limited scale (e.g. 15 to 40 %) and the presence of electrolytes in the material can give an error in the reading.



Moisture Meter

2. Importance of Air Humidity in Footwear Manufacture

2.1. Storage of leather

Leather contains water which acts as a lubricant on the fibers. The mechanical properties of leather (tensile strength, tear resistance, distension of grain, suppleness) are at the best level at a humdity content of about 14 per cent.

If leather is stored in a dry atmosphere, the air will take the humidity out of the leather and dry it out.

As chrome tanned leather is hydrophobic, it will be difficult, if not impossible, to give humidity back to the leather.

Lost of humidity in leathers sold by weight will give less yield.

2.2. Conditioning and heat setting.

Introduction of moisture into an upper leather will help the lasting process.

Storing of uppers in a cabinet or in a room where the atmosphere is near the saturation is a method to increase water vapor content in the leather. However this is a very rough and inefficient method. In addition to the fact that water vapor is difficult to introduce into the leather, the risks of staining are important.

Conditioning spaced uppers in a stream of water vapor gives better results but takes at least 20 to 30 minutes to be efficient.

The treated uppers must be lasted as soon as possible after being taken from the cabinet to avoid the quick evaporation of the moisture in the factory atmosphere.

Other ways for conditioning uppers are contact mulling and toe steamers. Efficiency of both methods depends upon the absorption capacity of the leather, particularly from its finish and from the presence and nature of the toe puffs and linings.

Heat setting can be done in fast drying of moist leather by I.R. radiation, high velocity hot air or vacuum drying.

In countries with high relative humidity in the atmosphere, leather is usually moist enough to be lasted and grain cracks are seldom. Therefore, the humidifying section of the heat setter is useless. Heat setting should only be concentrated on the drying phase. In wet climate, the only efficient and fast drying process will be under vacuum.

2.3. Drying of adhesive films

The solvents present in an adhesive are only there to allow application of the adhesive onto the materials. They must be completely eliminated before the junction of the shoe parts.

The rate of evaporation of solvents depends upon the R.H. in the atmosphere.

The higher the R.H. in the air, the lower will be the evaporation of the solvents.

2.4. Finishing

Some organic solvents in shoe polishes or finishing sprays are water miscible. If the R.H. in the atmosphere is too high (above 60-65%) finishes absorb water vapor, which will be condensed in the finish film and remove the gloss giving a dull appearance.

Note that this defect can also come from the presence of water in the air of the compressor.

Compressors and pipes should be drained periodically, and the water filters checked.

2.5. Storing, packing and shipping of shoes

Complains about mould or loss of gloss are frequent.

Due to the climatic conditions in the Philippines, special care should be taken in drying of the shoes,

- special care should be taken in drying of the shoes,
- packing in plastic bags should be discouraged,
- only wax, water, or non-water miscible solvent based polishes and finishes should be used,
- if water based adhesives (latex, starch) are used in any operation, the adhesive should be well dried.

For export to cold or temperate countries, only drying under vacuum is efficient (see 3.).

Placing of dehydrating crystals (silicagel) in shoe boxes will not help in drying.

3. Climatic Conditions

As the amount of water vapor in the atmosphere varies with the temperature, any change of temperature will influence the percentage of relative humidity, will result in changes in the water vapor pressure, and in some cases in the state of the water that can go from gaseous state to liquid or even solid state, and vice-versa.

The following table gives some values of maximum water vapor pressure in relation with temperature expressed in millimeter mercury.

- 4°C	3.30	6°	6.07	16°	13.51	26°	24.95
- 2	3.90	8	7.99	18	15.33	28	28.07
0	4.57	10	9.14	20	17.36	30	31.51
2	5.27	12	10.43	22	19.63	32	35.32
4	6.07	14	11.88	24	22.15	34	39.52

If we take a bottle of soft drink out of the refrigerator, we observe the condensation of water drops on the bottle.

If a person wearing spectacles goes from a very cold room to a hotter place, mist will condensate on his glasses.

This is because the cold bottle or the cold glasses create in the boundary atmosphere a zone of cooler air where the water vapor pressure (or water vapor absorption capacity) of the air is lower so that the water vapor condensate into the liquid phase (water drops) or the intermediate phase (mist).

In the same way, we find the explanation of the formation of clouds : evaporation of surface waters on the earth is invisible because air in contact with sea or river level is hot and can absorb a big amount of water vapor. Hot air has the tendency to raise and when it comes in the cooler regions of the atmosphere the water vapor condense and forms clouds.

The best way to introduce moisture into leather should be to cool the leather and bring it then in a cool and humid atmosphere. This is only applicable in cool countries. The first phase of heat setting (wetting) is an application of this principle.

Another phenomenon resulting from hygrometric conditions is the drying out of materials.

This causes big problem in cold climates where factories and buildings have to be heated during winter time.

Heating systems are based on air circulation. Cold air is taken out of the buildings, brought in contact with a heat generator and put in circulation inside of the building.

The cold air has a low water vapor content, even if the R.H. is high (during rainy or foggy days). When it is heated the water vapor absorbtion capacity raises and air will try to get humidity from anywhere, namely from moisture containing materials, such as leather.

For example, air at 0°C contains 4 grams water vapor per cubic meter. At 20°C the saturation capacity is at 14 g/m^3, so when the air is heated from 0 to 20°C there is a deficit of 10 g water vapor per m^3.

This explains the difficulties and accidents in lasting (grain cracks) during winter time.