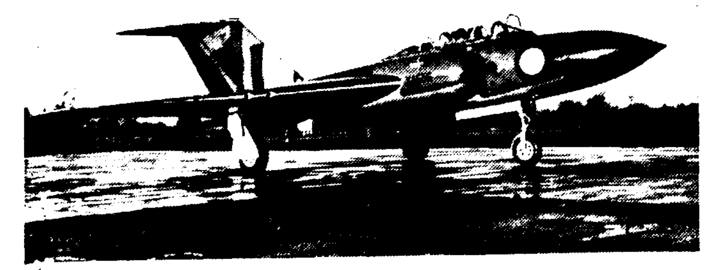
JOURNAL OF INDUSTRIAL ENGINEERING



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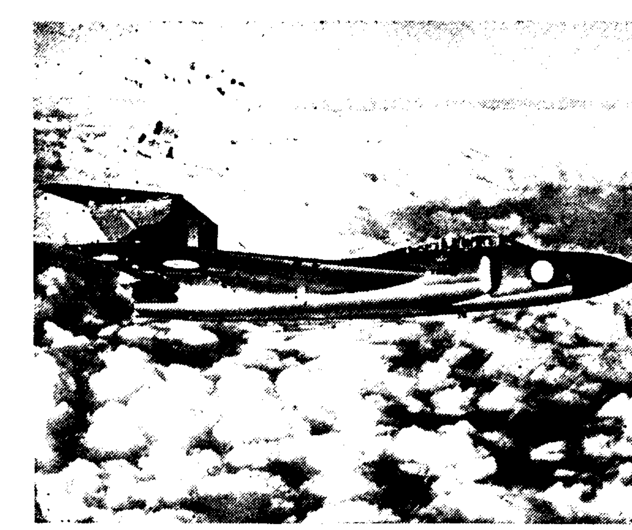

J.O.I.E.

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CAST IRON THAT BENDS

THE iron and steel industry is rightly regarded as the mother of industries and its progress an unmistakable index to the industrial growth of a country.

In India, this industry has been assigned a vital role in the industrial development conceived in the Five Year Plans that are blueprinting a new era of prosperity.

Strange as it may seem to be, it has now been possible, through the steady evolution of the process of casting iron that has taken place during this century, to produce a cast iron, that bends. Spheroidal graphite cast iron, as it is called, often replaces steel, malleable cast iron, and other materials and has found application in almost every branch of engineering practice. It is peculiarly responsive to all types of heat treatment and can be alloyed to develop special matrix structures and properties. It may be regarded as having its own "bank", from which carbon may be drawn or into which carbon may be deposited as desired.

In order to explain what is implied by spheroidal graphite cast iron, or as it is termed for convenience "S. G. Iron", a brief reference to the metallurgical nature of cast iron is imperative. The manner in which the carbon is associated with the iron, distinguishes steel from cast iron. The carbon content in grey cast iron ranges from 3 to 3.5 per cent of which all but a small proportion — generally 0.4 to 0.6 per cent — separates as free carbon in the metal on cooling. Thus an alloy of iron containing about 2.5 to 3 per cent (by weight) of free graphite, may be considered as cast iron. In ordinary cast iron this graphite is present in the form of thin flakes distributed throughout the metal.

In S.G. iron the graphite present takes the form of spheroids and they are isolated from one another. Processes developed in Europe and the U. S. A. during the last eight years, have established the commercial possibility of producing S. G. iron directly in the foundry. Briefly the production depends on the treatment, in the foundry, of a suitable grade of molten iron with magnesium or cerium, or both, as a result of which the graphite, which separates in the casting during cooling, assumes the spheroidal form in place of the normal flake type.

The immediate result of this change is that for a given type of iron, the strength is atleast doubled, the toughness and shock resistance are increased by several times, and many of the grades show an appreciable elongation in the tensile test, indicating considerable ductility. The damping capacity of the metal is also increased thus giving it an advantage over steel where it is desired to absorb vibration.

On the other hand, the castability of the metal remains unimpaired with the possibility of producing sound, dense castings of dimensional accuracy and with the minimum possible machining allowances. The machinability of S. G. iron is good and for a given matrix structure, it is roughly the same as for flake graphite iron. At equivalent hardness levels or at similar strength levels, S. G. iron is found to have better machinability than alternative materials and to permit 25 per cent higher cutting speeds under given conditions, though at a given hardness level, power consumption in machining is generally

somewhat higher than for ordinary iron, due to greater strength and toughness of the matrix, but tool life is greater. In the annealed state, the iron generally yields long continuous turnings similar to those obtained from steel. Other properties of cast iron, such as its wear resistance and self-lubrication, are largely retained.

With regard to its properties, there is already an extensive literature on the general subject of S. G. iron. Briefly, its tensile strength as cast is in the region of 40 tons per sq. inch and after annealing it falls to about 32 tons per sq. inch. It has a yield point of 25 to 35 tons per sq. inch as cast and 20 to 25 tons per sq. inch after annealing thus equalling the values for some types of cast steel. The modulus of elasticity of S. G. iron lies between those of ordinary cast iron and steel and is generally around 25 million pounds per sq. inch. In the as-cast condition the elongation is 1 to 3% which after annealing increases to 12 to 25%. The ductility has frequently been demonstrated by means of bent and twisted test bars. Although it can be bent, it is a rigid material and resists deformation except under heavy load.

The compressive strength of S. G. iron in the as-cast condition is generally between 60 and 90 tons per sq. inch and for the harder grades, the figure is higher. The shear strength of S. G. iron is high and a design figure of 90 per cent of the tensile strength can be taken. The toughness of S.G. iron is of great importance to engineers and it is replacing even cast steel for many applications where parts are subject to shock. With a dense structure, the hardness of the material is generally about 30 to 50 points Brinell higher than that of corresponding flake graphite iron.

S. G. iron may readily be welded and lends itself to all the known production techniques generally applied to high duty cast iron. Further, its weldability facilitates repair and the preparation of assemblies in S. G. iron or composites with other materials.

The facility with which it can be plated and enamelled makes it suitable for many items of decorative trim and chemical plant. It is readily "tinned" and this property, in combination with its high strength and its inherent good bearing properties, makes it ideal for bearing shells thus successfully replacing in many instances bronze or steel.

On account of its properties, S.G. iron is now entering into every field of engineering practice and there is no major industry in Europe or U. S A. not already using it. It has found numerous applications in agricultural machinery, electrical industry, automobile and railway engineering, textile machinery, engines of all types, in steam and gas turbines and other power units which cannot be detailed.

Of more direct interest perhaps to the Indian industry specially the one engaged on machine tool building, is the growing application of S. G. Iron for structural parts of machine tools. Safety, accessibility and compactness are obvious "musts" in machine tool building industry and these are easily obtainable by using S. G. Iron. For highly stressed structural components of machine tools, for which steel is presently employed for reasons of strength, S. G. Iron may offer advantages in providing strength approaching that of steel with better damping capacity.

(Continued on page 4)

Mechanical Stoking Practice in Shell Boilers

By S. B. Sarkar,
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Jamshedpur - 4

WITH many types of Steam Boilers we come across, these can fundamentally be divided into two principal groups: those in which the Furnace is surrounded by water and steam—shell boilers and other in which the products of combustion is external to the heating tubes, through which water flows—water tube boilers.

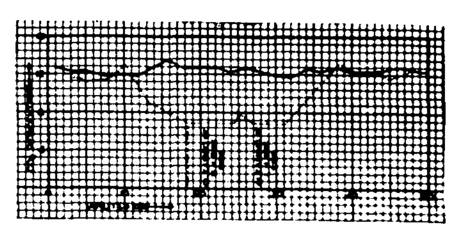
Upto an Evaporation of 15000 lbs. per hour of water, internally fired shell boilers are widely in use. Lancashire and Vertical type of Boilers in this group are very often used in the collieries, small and medium sized chemical and engineering works where a working pressure exceeding 250 lbs. per sq. inch is seldom needed. A shell boiler fitted with an economiser and superheater can be hand fired with a Thermal Efficiency of 70 per cent; but this requires greater skill than is normally available, and if it is correctly estimated, it will be found that the average efficiency of hand fired shell boilers in India is less than 55%. The loss of fuel due to less efficiency in shell boilers in India amounts to millions of tons of coals per year and the need to eliminate this wastage is the predominating factor in favour of Mechanical stoking in the shell boilers.

Comparing hand and mechanical-firing on two similar boilers, the advantages claimed for mechanical firing are as follows:

1. Output of steam from the boiler can be increased by mechanical stoking.
2. An increased thermal efficiency of 10 to 15 % can be achieved when compared to hand firing.
3. The work of the Boiler Attendant is much more simplified and interesting.
4. Loss of efficiency due to incomplete combustion is very easily avoided with the elimination of smoke nuisance.
5. A wider scope of Instrumentation for Automatic control to help in maintaining a constant rate of Evaporation and pressure is available.

In a hand fired Boiler, the furnace door is opened everytime for firing the fuel, cleaning the fire and removal of ash, when the equilibrium of combustion is upset for a while disturbing the percentage of CO_2 in the products of combustion and the temperature of the Boiler Furnace. The following graphs show how disturbing the conditions of CO_2 and Temperature are in a Boiler when it is hand fired compared to that fired by a Mechanical Stoker.

CO_2 PERCENTAGE IN THE FLUE OF A BOILER FURNACE



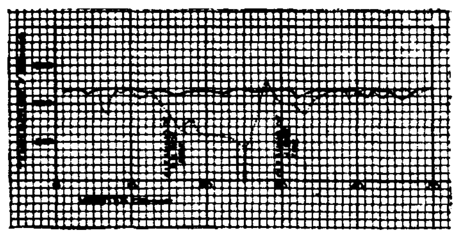
— *In a Mech. Stoker.*
.. *In case of hand Firing.*

(Continued from page 3)

One of the earliest applications of S.G. Iron in U.S.A. was for hammer blocks and anvils on drop forging machines, as well as for side frames. In Switzerland, S.G. iron has been successfully employed for small rolling-mill housings, and one of the most important uses of S.G. iron is for metal-working rolls for both hot and cold rolling of sheet and strip.

This fascinating material offers a very wide scope of application and it is hoped that our engineers and designers, by their progressiveness and adaptability and readiness to keep abreast of modern trends, will explore this new material in their own applications in various industries with which they are connected.

TEMPERATURE VARIATIONS AT THE END OF THE FIRE TUBE OF A LANCASHIRE BOILER



— *In a Mech. Stoker.*
.. *In a Hand fired Blr. Furnace.*

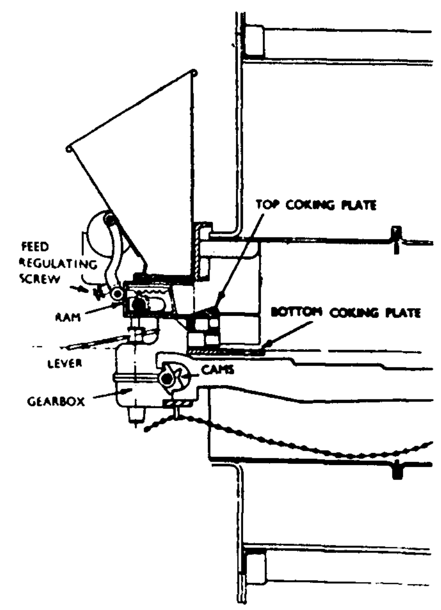
The burning of coal on a grate is a complex progression of physical and chemical changes, in the course of which carbon, hydrogen and sulphur combine with atmospheric oxygen with a liberation of heat. The amount of air required to burn any coal as calculated from the composition is not however sufficient in practice to ensure complete combustion. The quantity is only an approximate guide to the actual need, as from 40 to 50% of excess air is necessary to ensure complete combustion in the shell boilers. In a hand fired boiler, due to an uneven fuel bed and fuel size, distribution of air is not perfect at all part of the grate; so a consistently high percentage of Co_2 in the waste gases is not by itself an indication of good combustion. A practical test of high efficiency is a high Co_2 content in the Fuel gases, accompanied by an almost complete absence of smoke at the chimney top, which are ensured in a Boiler fitted with a mechanical stoker and operated carefully.

There are four types of Mechanical Stokers available in the market, (i) Chain grate, (ii) Coking, (iii) Sprinkler mechanisms with moving or stationary grates and (iv) Underfeed. But these may be broadly classified into two classes. One in which coal is fed from above grate level, known as overfed stokers and the other in which coal is fed from below grate level, known as underfeed stokers.

In a coking stoker, coal is pushed forward on to a horizontal plate, where it is heated and partly coked before being displaced by a new charge to fall on to the front of a moving grate. Coking machines and sprinkler type mechanism have several features in common; the supply of coal is arranged in a hopper in front of each firetube. The coal charging mechanism is fitted into a small horizontal chamber below the hopper, and consists of a slow moving ram which travels a few inches backwards and forwards. On the backward stroke, an opening is disclosed in the base of the hopper, a charge of coal falls through and is displaced on the forward stroke into a second chamber by the ram.

COKING STOKERS

With coking stokers, coal is fed on to the front of a moving grate by way of a coking plate located above the firedoor. The method is most effective with medium coking coals. Strongly coking coals tend to form lumps which does not readily break. Free burning coals do not cake and are not suitable on coking stokers.



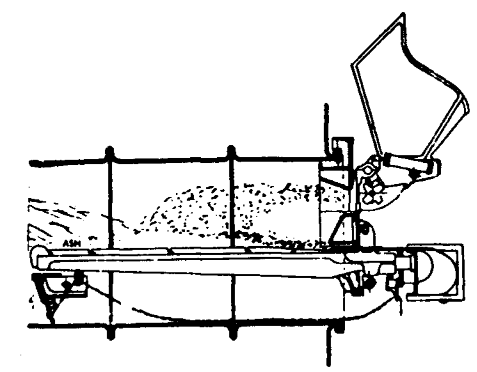
A coking Stoker.

SPRINKLER STOKER

This type of mechanism consists of two parts; a sprinkler feeding device and a gear unit. This may be used with a stationary grate or a moving self-cleaning grate and with forced draught.

In this type of stoking, a moving grate uses a spring loaded shovel with three or four throws of different length, with a preset maximum length of throw so that coal is spread over the full length of the grate, a suitable distance at the rear being reserved for the completion of burning off before the ash is discharged. The combination of a sprinkler along with a moving grate and a fan draught is ideal to achieve fuller efficiency in steam raising. The rate of feed may be varied from 0 to 20 cwt. per hour in a Typical 'Bennis' sprinkler stoker which is illustrated below. The only disadvantage of this mechanism is, unless the

timing of the feeding ram relative to the shovels is checked from time to time in case of a shovel type stoker, the ram may operate too early, that is before the shovel has returned to its 'cocked' position, coal will fall on top of the shovel and a certain amount will work over behind it; an accumulation of coal behind the shovel jams the machine. But with slight care and time setting, the difficulty is easily overcome.

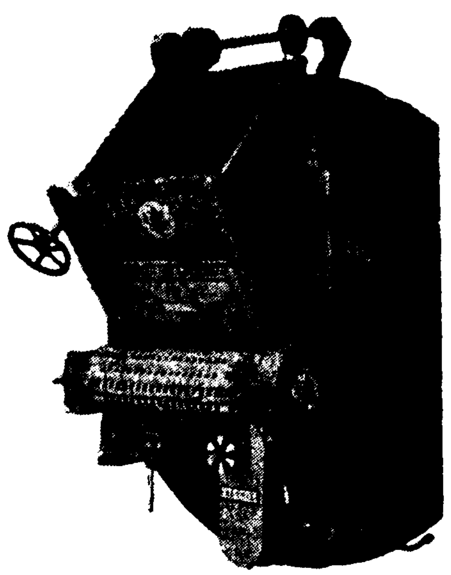


A Sprinkler Stoker attached to a Lancashire Boiler.

CHAIN GRATE STOKERS

In the design of shell boilers, the fundamental limitations in design arise from the need to arrange the furnace with its fire grate, together with sufficient heating area and a steam space within the shell. In a Lancashire type of boiler, the diameter of the furnace tubes is limited by this to about one quarter of the diameter of a small boiler and about one third of a large boiler. So the availability of space for accommodating a right size of grate was a problem. But the grates of proper size suitable for rapid combustion with the aid of induced draught burning 20–30 lb. of coal (medium grade) per hour per sq. ft. of grate area have now been successfully marketed. It is best suited for high volatile, free burning coals with a fairly large ash content. The grate is suitable for firing coal which passes through 1" mesh with fines to form a compact fuel bed.

A chain grate stoker is mainly comprising of the (a) grate surface made of Die-cast heat resisting cast iron links, (b) Drive which is essentially a chain drive to a machine-cut Worm and wheel driven by a totally enclosed variable speed D. C. Motor, (c) the frame which is a steel unit of welded construction serving the purpose of Air box as well, and (d) the hopper which stores coal with the arrangements for fully extending the fuel feed over the full width of the grate.



A front view of a Chain Grate Stoker.

UNDERFEED STOKERS

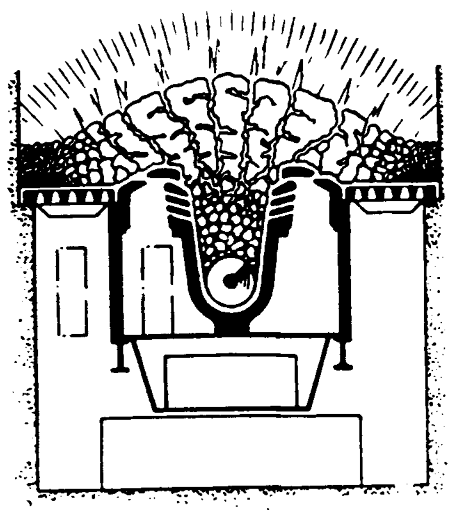
Features of an underfeed stoker are mainly:

(a) a Hopper which stores coal, capacity of which is determined by site considerations and the requirements,
(b) a worm conveyor screw made of chrome manganese Alloy Steel Castings,
and (c) a drive by an Electric Motor with a high reduction of speed by means of a gear box.

Air is usually supplied by a Low pressure vane type centrifugal Fan. The design of the Retort on the grate is a very important factor which determines the nature of combustion, whether this will be smokeless or not. A simple design of a Retort is shown below, provided with a divided Air Supply in two sections—one supplying the tuyeres and the other surrounding the grate, which provides additional advantage of easy removal of Ash from the Air cooled surface.

Combustion in an underfeed stoker is advantageous from the point of view of its

(a) unrestricted ignition of a fuel,
(b) a uniform distribution of air and fuel all over the grate,
(c) a uniform depth of fuel,
and (d) no room for any blow holes in the fire. But the fuel should be chosen of uniform range of sizes in proportions so that the flow of air through the fuel bed and ignitability remain uniform at all parts of the bed.



A Retort for a vertical boiler.

Automatic controls are widely in use along with the underfeed type of stoking to operate on 'stop-start' principle. The boiler is provided with a Pressurestat which breaks an Electrical circuit and stops the stoker-motor when the steam pressure reaches the desired level, and re-starts the circuit when the steam pressure goes down by a preset amount. The rate of the coal feed is set in excess of that required to meet the peak load with an appropriate setting of the Air Control. The coal feed and Air feed are both interrupted when the power to the Motor is cut off. These are provided with a hand control as well, for use at the time of starting or an emergency.

An underfeed Stoker fitted to a vertical boiler.

In the Eastern Part of the country where the coal is in abundance, it is almost everywhere wasted by indulging in an inefficient hand-firing. Specially the wastage in the colliery boilers will amount to a sizable figure. All these could be conserved with the gradual introduction of a suitable form of Mechanical stoking to these boilers. Again, in the western India where coal is quite a costly Boiler Fuel, the mills and other industries today prefer Fuel-Oil for their Boilers. The cost of coal in Bombay is Rs. 40/- to Rs. 45/- per ton whereas the cheapest Fuel Oil (Furnace Oil) costs Rs. 156/- per ton. Under the present price structure, the cost of oil firing should not be more than 2.1 times that of Mechanical Stoking to speak in favour of oil firing for steam generation in the Shell Boilers. This also takes into consideration the problems of coal and Ash handling and more labour involved in the coal firing. If the cost of fuel oil is more than Rs. 100/- per ton, the mechanical stoking of boilers should be profitable anywhere in this country.

The following are the test results: one on the oil firing and the other using a Mechanical stoker in the same type of boilers. This amply clarifies the need for a Mechanical stoker for all shell type stationery Boilers.

Test Results of an Oilfired Cochran Boiler fitted with Keymer Bagshawe L. A. P. Burners.

Duration : 4 Hours.

Total Heating Surface : 160 Sq. ft.

Oil:	Temperature of oil in the oil tank ..	77°F
	Temp. at the burner end ..	146°F
	Consumption per hour, lbs. ..	60.75
Water:	Water Evaporation/Hour, lb. ..	698.5
	Steam Pressure in Boiler, lb./Sq. In. ..	50
	Lb. of water Evaporated/Lb. of oil	11.5
	Calorific Valve of oil ..	18540 (Gross)
	Co_2 in Flue Gas ..	13.7%
	Smoke ..	Traces
	Air Temperature at the Burner ..	192°F
	Thermal Efficiency of the Boiler ..	72.5%

Test results of a similar boiler fitted with a " Hopes " Screw Type Underfeed Stoker:

Duration : 4 Hours.

(Continued on page 9)

Which Stamped Retaining Ring?

By Heinrich Heimann
Waldes-Kohinoor, Inc.

Construction and application of basic kinds of retaining rings. Width and depth of grooves required, thrust limitations, and amount of end play that can be taken up.

AMONG the existing methods of fastening and/or locating machine parts or components in an assembly, retaining rings or snap rings have a unique advantage: They can be snapped into any properly designed circumferential groove to form an artificial shoulder. Being hard-tempered springs, their shearing strength—and therefore their thrust and impact capacity—is high. Consequently, they can be used to replace nuts, machined or pressed shoulders, collars, cotter pins, or other positioning or thrust devices, often with one or more of the following results:

1. Quicker assembly and disassembly of component parts. (Accurate positioning of the components relative to the groove without danger of marring the surface.)
2. Reduced machining and grinding operations. (Substitution of centerless grinding for machining and plunge grinding and elimination of threading, tapping, and drilling operations.)
3. Simplification of design. (Reduction in the number or complexity of parts in an assembly.)
4. Reduced size. (Thin rings replacing heavier nuts and shoulders.)
5. Elimination of looseness or end play resulting from accumulated tolerances, or from wear in service.

BASIC TYPES OF RETAINING RINGS

There are two basic types of retaining rings: One, a bent wire ring of uniform cross section; the other, a tapered circular ring that is stamped from strip or sheet stock. The former is more economical to make since only a small amount of scrap is produced by the cutting and forming operation. If properly selected, the thrust and impact capacity of these rings usually is satisfactory because the shear strength of the material is relatively high and the ring thickness may be chosen according to requirements. In any case, the thrust and impact capacity of the ring exceeds that of the groove, which is usually cut in cold-rolled steel, cast iron, or bronze. However, an analysis of the working stresses occurring in spreading or contracting a wire ring shows that it may take a permanent set unless it is carefully dimensioned and handled. Radial thickness or section height for a given degree of spreading or contracting has to be comparatively small so that the working stress in the ring does not exceed the yield strength of the material of which it is made. That means that either a shallow groove is required when a large protruding shoulder is necessary, or that a

(Continued from page 8)

Coal:	(Proximate Analysis) (Jamuria Steam Coal)	
	Ash ..	11.81
	Volatile Matters ..	34.61
	Fixed Carbon ..	53.58
Calorific value	..	12690
	Consumption per hour, lb. ..	79.5
Water:	Temperature of feed water ..	89°F
	Water Evaporation/Hr., lb. ..	708.5
	Steam Pressure in the Boiler (Lb./Sq. in.) ..	55
	Calorific value of coal (Dry Basis).	12690 (B. T.U./lb.)
	Percent Co_2 in the Flue Gas	12.3
	Smoke	Hazy look.
	Lb. of Steam generated/Lb. of coal	8.9
	Thermal Efficiency of the Blr.Plant	71.8%

smaller shoulder must be used when a deeper groove is imperative.

The main features of stamped metal rings, Fig. 1, are a tapered radial width, symmetrically decreasing from the middle section to the free ends of the ring; and apertured lugs at the end for ease of application. The eccentricity of the inner and outer circular edge of this type of rings—external rings for shafts and internal rings for housings—govern the deformation of rings under spreading or contracting forces. These rings stay circular under deformation as long as the working stresses do not materially exceed the yield strength of the spring material. As each ring portion is subjected to the same degree of deformation, the largest possible spread or contraction is reached with the smallest possible working stress. That means that for a given maximum section width—determined by the necessary shoulder height to abut a machine part effectively—the maximum degree of spreading or contracting, as expressed in a percentage of change in ring diameter, is approximately 10 percent of the free ring diameter in accordance with standards NAS 50 and 51, set up for the aviation industry by the National Aircraft Standards Committee. It is obvious that, owing to such a relatively large degree of spreading or contracting, the rings can be used even with relatively large variations in shaft and housing as well as in groove diameter.

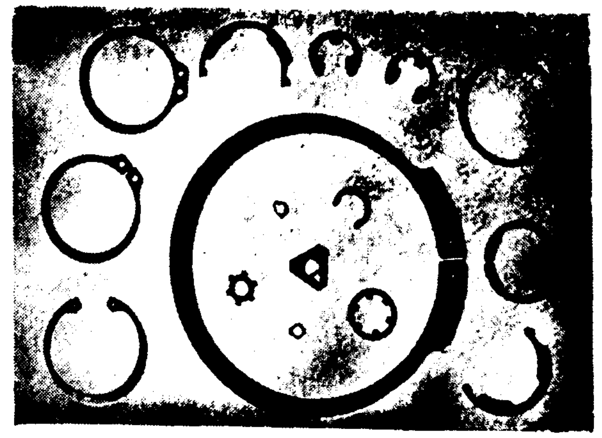


Fig. 1—Stamped metal retaining rings of different types and sizes. Sizes range from $\frac{1}{8}$ to 10 in. for standard rings; types depend on application requirements, such as rotational speed, axial take-up, shaft accessibility, and the ease of installation and removal.

As far as the static thrust acting on the ring assembly is concerned, not only the strength of the ring itself but also the strength of the seating groove has to be taken into consideration. The maximum static thrust the assembly can take is determined by whichever is weaker—the grooves or the ring. If the groove is cut in relatively soft material such as cold-rolled steel, brass, or aluminum, the groove is weaker than the hardened ring. The compressive strength of the soft material is much less than the shearing strength of the hardened ring (a ratio at least 1 : 2). Also, the standard groove depth and thus the height of the groove wall is less than the ring thickness. Therefore, for high static thrusts the shaft or housing generally should be through-hardened or case-hardened to increase the strength of the groove wall to approximately that of the hardened ring.

By consulting standard tables giving the ultimate shear strengths of material commonly used for stamping rings, it is easy to compare the thrust capacity of both ring and groove with the ultimate load the ring assembly is exposed to in service and to find out whether the assembly is strong enough or if an increase in ring thickness, groove depth and/or groove hardness is advisable.

What is true of thrust loads is also generally true of impact loads. Test results have shown that the maximum impact a ring can withstand—in inch pounds—is equal to one-half the maximum thrust capacity of the ring multiplied by the ring thickness, or

$$P_i = \frac{Pt}{2}$$

This formula, which can also be derived mathematically, is accurate within an approximate hardness range of 42 to 54 Rockwell *C*. Under similar considerations, it has been found that the maximum impact the groove can take equals $Pd/2$, wherein P is the maximum thrust that the groove wall can withstand and d is the groove depth. While a ring under the maximum impact according to the formula $Pt/2$ breaks through, the groove wall under the maximum impact $Pd/2$ is entirely deformed and flares out conically. In the first instance, i. e., when the impact strength of the ring does not exceed the impact strength of the groove, the ring does not lose its seat in the groove but breaks; while in the second instance—the impact strength of the groove being less than the impact strength of the ring—the ring will, on account of the conical deformation of the groove wall, slide over the groove wall and jump off. To be on the safe side, the permissible impact on ring or groove should not exceed one quarter of the maximum impact load that the ring or the groove, respectively, can take. With this safety factor, it is certain that the impact stresses on the ring or the groove wall will not exceed the allowable limit for working stresses.

BASIC TYPES OF STAMPED RINGS

Stamped rings are made in several different types, each of which has certain advantages and limitations. The standard type is similar to those shown at (A) and (B), Fig. 2.

These units are suitable for most general applications and are available in sizes ranging from $\frac{1}{8}$ to 10 in. for shafts and from $\frac{1}{4}$ to 10 in. for housings. A fair idea of the number of available sizes can be gathered from the fact that there are approximately 30 standard diameters listed between $\frac{1}{8}$ and 1.0 inch. Rings of the standard type up to 18 in. also can be and have been manufactured.

There are cases in which the non-uniformly protruding shoulder of the standard ring is objectionable, for instance, if machine parts with large chamfers or corner radii or with curved end surfaces have to be abutted. For such assemblies, the so-called "inverted" ring (C) and (D), Fig. 2 has been developed. The taper of this ring is reversed, that is, it does not lie at the side of the protruding ring shoulder but at the side of the groove, resulting in a uniformly protruding ring shoulder all around the ring circumference which is high enough to abut satisfactorily machined parts with large chamfers or corner radii. This type of external and internal ring is available for shaft sizes up to 4 in. in diameter only, since the minimum shoulder height of the standard ring is sufficiently high in larger sizes. The ultimate thrust capacity of these rings, due to the diminishing arc length of the abutting groove wall, is approximately $\frac{2}{3}$ that of the standard ring. The groove depth, as with standard rings, should approximate 2 to 2.5 percent of the shaft or housing diameter.

It is obvious that deviations in ring thickness, over-all length of the abutting machine part, and location of the groove may add up to some clearance between the abutting surface of the ring and the corresponding machine part to be located. To overcome this end play or clearance between ring and machine parts, two special modifications of the standard stamped rings have been developed. The first type is the so-called bowed ring which is bent out of its plane around its horizontal center line. The bowed ring acts in an axial direction as a floating spring, but without losing its tight grip against the bottom of the groove in radial direction. For relatively small assemblies involving shaft or housing sizes not over 1.5 in., this bowed ring is an effective means for taking up end play resiliently and for damping vibrations and oscillations. This modification is shown in sketches (E) and (F), Fig. 2; Obviously, the groove width for bowed rings has to be larger than the groove width for standard rings by an amount equal to the height of the bow.

Another modification of the stamped ring used to minimize the problem of end play is the so-called beveled ring as shown in sketches (G) and (H), Fig. 2. The groove-engaging edge of this ring is tapered or beveled under a small angle (about 15 deg.) and abuts against an outer groove wall that is tapered at the same angle. With a load on the ring, the tapered edge acts like a wedge so that the ring, expanding or contracting more deeply into the groove, is shifted to a certain degree in the axial direction until it abuts against the machine parts, thus bridging end play rigidly. The angle of the wedge-like edge being smaller than the angle of repose, the ring is locked in its end position against axial thrusts exerted by the machine part. It thus is obvious that this ring takes up the end play rigidly.

When a shaft is axially inaccessible, none of the aforementioned rings can be positioned in its groove. For such constructions, open rings that may be snapped in place across the shaft directly in the plane of the groove are required. Two types of such rings have been developed. A so-called "crescent" ring is shown at (T) in Fig. 2; this is an open ring the section width of which diminishes according to the same rules as set forth for the standard ring. The taper of the ring results in two favourable properties: First, due to its circular deformation, the ring always maintains a tight fit against the bottom of the groove; second, the length of the free legs is increased correspondingly. The taper of this ring is directed against the bottom of the groove so that there is a uniform shoulder all around its encircling length. The section width of this modification is obviously subject to certain limitations depending on the working stresses the ring is exposed to when being snapped into place. The working stresses

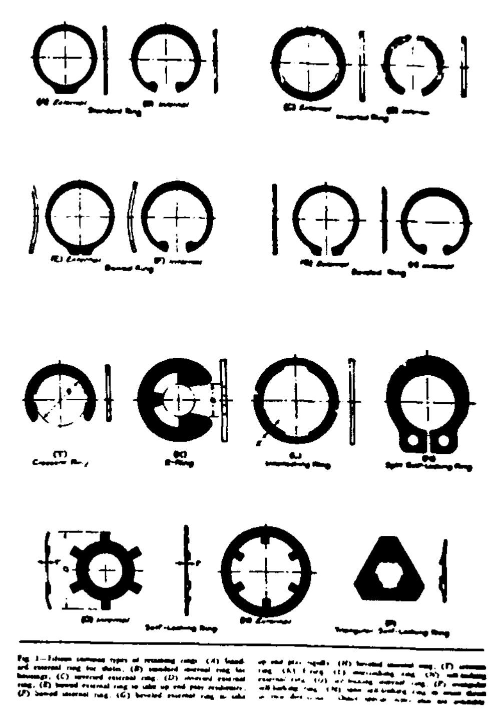


Fig. 2.—Fifteen common types of retaining rings: (A) Standard external ring for shafts; (B) standard internal ring for housings; (C) inverted external ring; (D) inverted external ring; (E) bowed external ring to take up end play resiliently; (F) bowed internal ring; (G) beveled external ring to take up end play rigidly; (H) beveled internal ring; (T) crescent ring; (K) E-ring; (L) interlocking ring; (N) self-locking external ring; (O) self-locking internal ring; (P) triangular self-locking ring; (M) split self-locking ring to resist thrust in two directions. Other special types also are available.

should in no case exceed the yield strength of the material to avoid a permanent set and a loosening of the ring in the groove—especially dangerous in the case of open rings.

A second type of open ring which is free of the limitations of the crescent type is the E-ring illustrated in Fig. 2 (K). This ring is provided with three inwardly protruding prongs, spaced approximately 120 deg. apart, that abut the bottom of the groove. The radius of the bending arms is considerably larger than the radius of the groove so that a relatively deep groove may be provided and a high protruding shoulder obtained. This E-ring is also available as a bowed ring to take up end play resiliently between the ring and the machine part to be located.

Open rings are not recommended on shafts rotating at high speed because the centrifugal forces acting on them may exceed their clamping power and the rings may jump off the groove. When the speed of the shaft is higher than this limit, a two-part

interlocking ring such as shown at (L) in Fig. 2, may be used. This ring is locked in position by engaging hooks on the two parts and the shear resistance of these hooks is sufficiently high that the ring is secure under practically any rotational speed encountered. It is obvious that the depth of its groove is independent of the shaft diameter since the ring halves are assembled in the plane of the groove across the shaft. Also, the section height of the ring and, therefore, its abutting shoulder may be relatively high because of the small degree of spreading the ring halves are subjected to in assembly and because of the space in the middle part of the ring halves.

All the rings so far discussed require a groove in the shaft or housing. But it is not always possible or advisable to groove a shaft or a housing in such small devices as instruments or small business machines. Usually in such assemblies the shoulder need not absorb considerable thrust but rather must serve merely as a holding device against small vibrations or impacts. A ring has been developed that has enough holding power in one direction and may be slipped over the shaft or into the housing in the opposite direction exactly to the desired place, i. e., against the face of the machine part to be held in place; internal and external types are illustrated at (O) and (N).

Characteristic for both external and internal types of this closed—not split—ring are inwardly or outwardly protruding, slightly inclined prongs that abut against the outer surface of the shaft or the inner surface of the housing and which, due to their inclination, allow assembly in one direction in which their inclination tends to increase, but develop holding power in the opposite direction where the inclination of the tongues tends to decrease.

A further type of external self-locking retainer that can be assembled on a shaft or pin without grooving is the so-called "triangular ring", (P) Fig. 2. Three slightly inclined prongs, spaced at 120 deg. protrude from the triangular ring body. The side portions connecting the prongs may be slightly bent out of their plane. Functionally characteristic for this type of ring is its high thrust and impact capacity and the considerable variations (tolerances) in shaft size it permits.

The self-locking rings discussed above and provided with a closed ring body act as self-locking retainers in one direction only. But there is also a need for a ring assembled on a straight non-grooved shaft or in a straight non-grooved housing which locks in both directions. For this special purpose, a split ring has been developed that may be assembled with pliers like a standard ring. This split ring shown at M, is so dimensioned that it exerts a pressure against the surface of shaft or housing high enough to produce, in both directions, friction forces that withstand moderate thrust loads or impacts. The simplicity of this ring and of the way in which it is handled makes it a successful substitute for small collars which are frequently employed as locating means in light machinery, business machines, instruments and the like.

The previous description of standardized types of stamped rings is by no means exhaustive. For the solution of special problems submitted by the industry, special rings that deviate from the standard types in both form and function have been developed. But for the main problems encountered in practice, these standard types are sufficient and satisfactory. In many cases, their application will result in simple design and lower cost.

High-voltage Selenium Rectifiers

By L. Borg
Rectifier Design Dept., Sweden.

THE CONDITIONS GOVERNING THE USE OF THE SELENIUM RECTIFIER FOR HIGH-VOLTAGE PURPOSES

WHEN the generation of high direct voltage of moderate power (up to a few tens of kilowatts) is required, recourse may be had to electro-static generators, rotating spark gaps, electronic valve rectifiers or semi-conductor rectifiers, which are now usually of selenium type.

The electro-static generators, for example van de Graaf machines, give only low current, but can, on the other hand, be constructed for very high voltages. They are, therefore, mainly used for laboratory purposes, for atomic research, *etc.*

The rotating spark gaps, which act as mechanical rectifiers, have a load capacity of up to a few tenths of an ampere. Because of wear on the electrodes, they require much attention if they are to function reliably. They cause considerable radio interference and require a relatively large amount of space.

The electronic valve rectifiers require least space, but their load capacity is moderate, and the electronic valve must be changed from time to time..

The selenium rectifiers, if oil-insulated, also do not require a great deal of space. If they are suitably dimensioned, they have a long life, and, thanks to the large thermal capacity of the oil, a very large overload capacity. Their most economic range at high voltages extends from about 10 mA up to about 0.5 A. The only attention which they require is the normal cleaning recommended for all electrical apparatus. The selenium rectifier can be suitably controlled by means of transductors.

CONNECTIONS

Fig. 1 shows the various connections which can be adopted in the case of high-voltage selenium rectifiers.

Fig. 1a, the half-wave circuit, is the simplest, and it is the most suitable one for low currents, 10—20 mA. The direct voltage pulsates strongly unless there is sufficient capacitance to smooth the voltage. In many cases, the capacitance of the load and the leads may be sufficient, especially if there is a cable, but otherwise a capacitor can be used. At high currents, the smoothing capacitor may be unreasonably large and the D. C. magnetisation to which the transformer core is subjected is a disadvantage.

For rather higher currents, the circuit as in *fig. 1 b* may therefore be favourable. It is called the "voltage-doubling circuit" or the "Delon circuit"

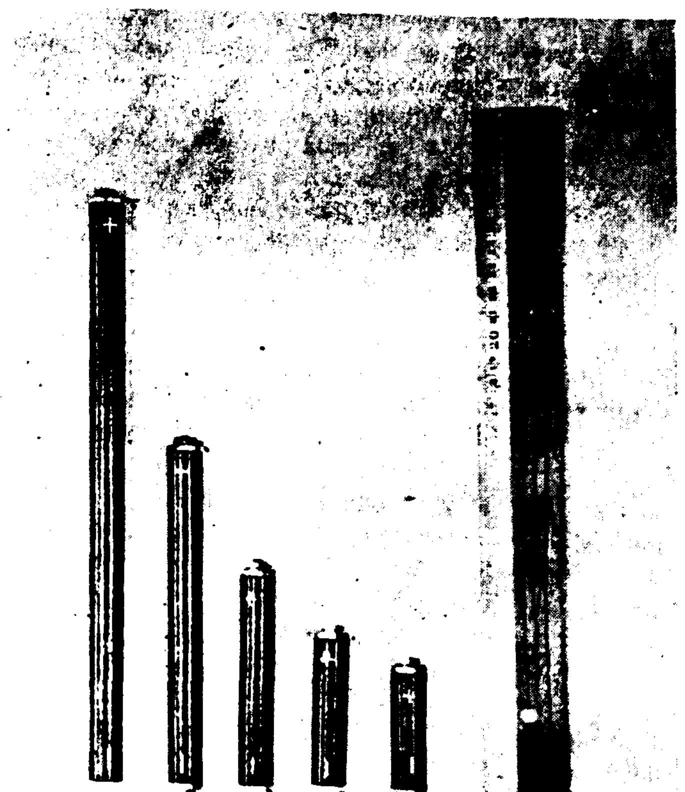


Fig. 3. Selenium valves type RYBA consisting of single stacks in bakelite tubes. The permitted reverse voltage on the valves from left to right is 3,600, 1,800, 900, 450 and 225V peak value respectively (34221).

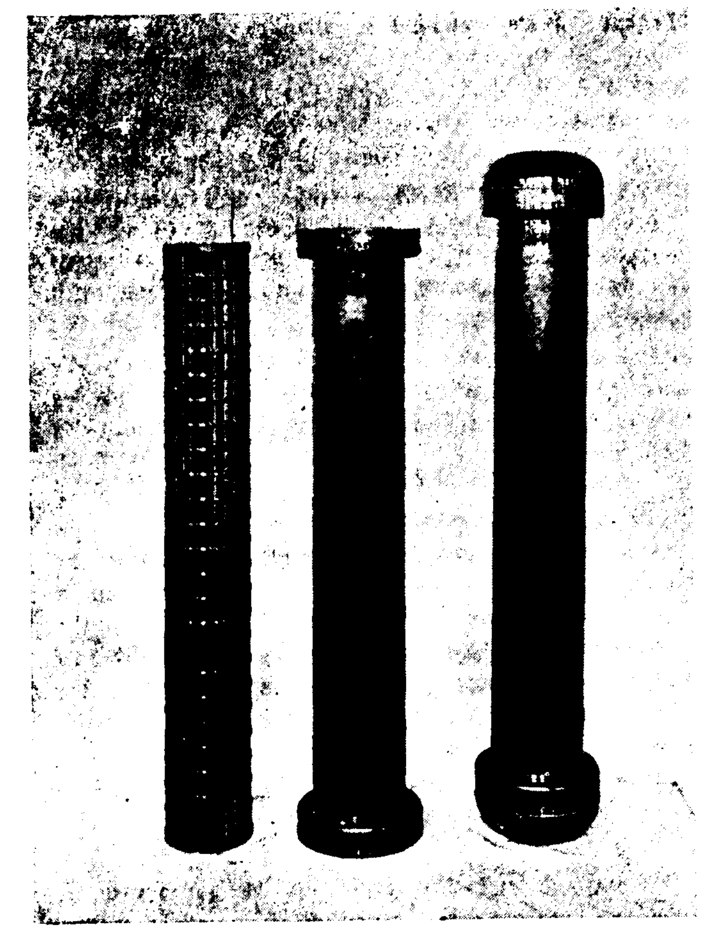


Fig. 4. Oil-cooled selenium stack type RYAB for a reverse voltage of 200kV peak value, to the left the assembly of the small stacks, in the centre the bakelite tube and, to the right, the complete stack. (39904)

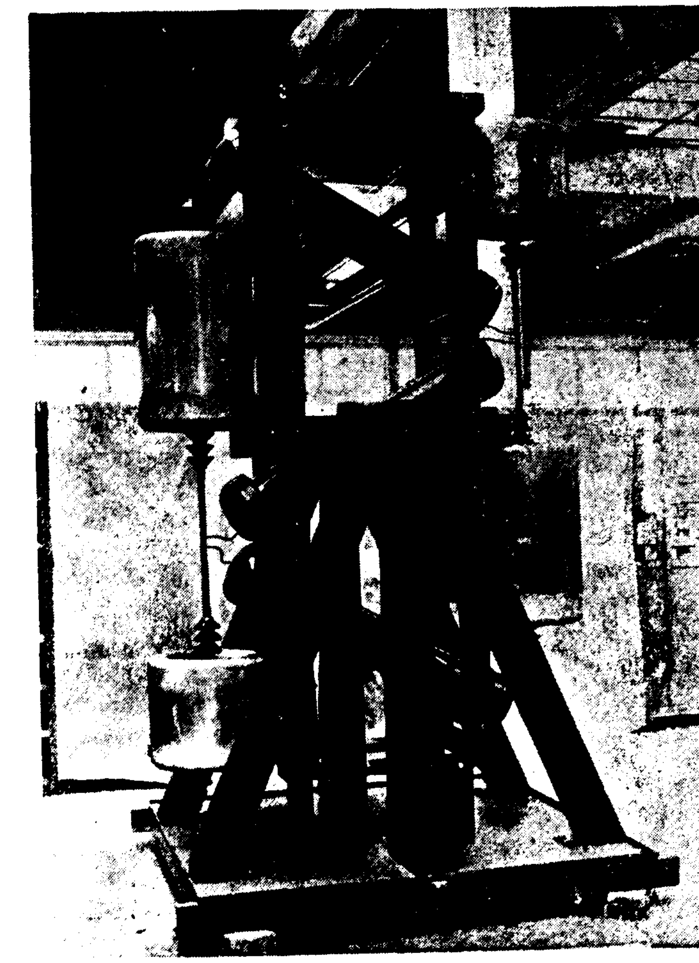


Fig. 5. An example of how a cascade rectifier can easily be built up of RYAB stacks and capacitors. The framework is made of wood. (35238)

and has the characteristic that the direct voltage at no-load is twice the peak value of the transformer voltage. On the other hand, the current conditions are less favourable and the suitability of the circuit is therefore limited to the order of 50 mA. Above this value, the capacitor rating required would be excessive.

At higher currents, the choice is between *fig. 1c*, the single-phase bridge, and *1 d*, the three-phase bridge. The choice between these two is mainly an economic question and, as a rule, at high currents, the three-phase circuit is to be preferred.

At very high voltages, above about 200 kV, a circuit as in *fig. 2* may be used with advantage, *i. e.* a "cascade circuit" or "Greinacher-Villard circuit". With a circuit of this kind it is possible to get a no-load voltage equal to the peak value of the transformer voltage multiplied by the number of valves. The load capacity is, however, limited, but at the high direct voltages (theoretically unlimited) which are under consideration here, the current load is normally moderate. The selenium valves have the especial advantage here over the electronic valve that the problem of supplying filament current at several different levels of potential is avoided.

MECHANICAL DESIGN

A selenium valve is built up of a number of valve elements connected in series or in parallel. Each element consists of a selenium plate and contact devices. A very large number of plates connected in series are required to make a valve for high voltages. The plates are mounted together in various ways in stacks and with the necessary clamping and contact devices. Suitable contact pressure is obtained by means of spiral springs, and this is particularly important in the case of service in oil.

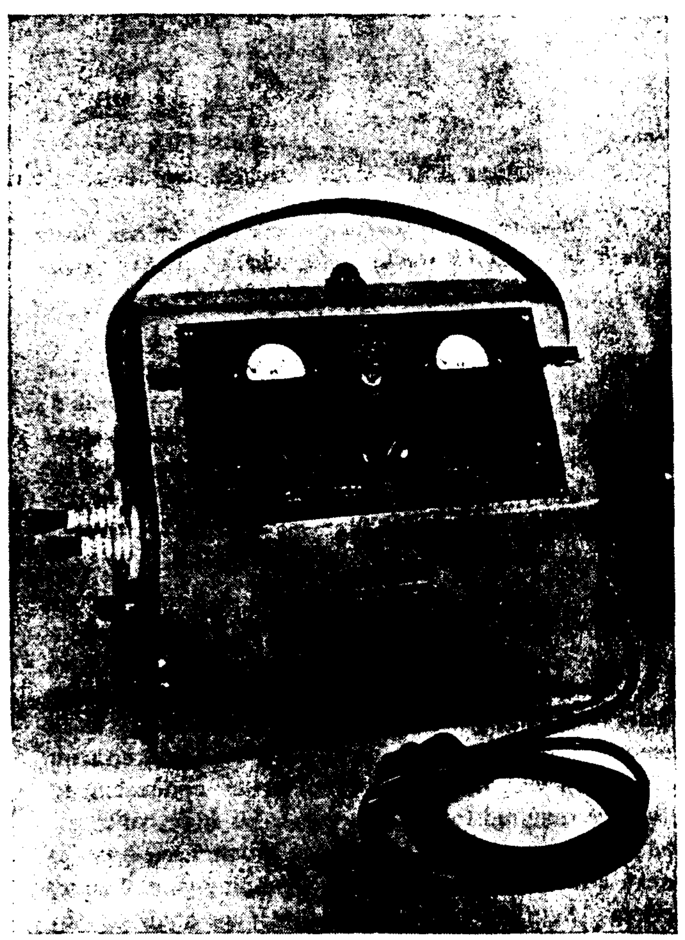
For use in air, ASEA manufacture a series of simple stacks in bakelite tubes as in *fig. 3* with the type designation RYBA, which may be loaded continuously with an R. M. S. current of 23 mA. The standard series comprises stacks with reverse voltages from 225 to 3,600 volts peak value. With four of these stacks in a single-phase bridge, it is possible to obtain a direct current of 30 mA continuously with resistive load. These stacks are intended to be built into other apparatus for a variety of purposes, an example being shown in *fig. 6*.

However, for high voltages, a stack designed in this way would be much too bulky, and for such purposes ASEA manufacture a larger valve with the type designation RYAB, as shown in *fig. 4*. An oil-filled bakelite tube serves as a frame and it has oil-tight end seals which also serve as connections. The selenium plates are divided up into a large number of small stacks, placed in storeys around the inside of the tube. The stacks in each storey are connected in series and the storeys too are also connected in series. The oil can expand in the case of temperature variations, thanks to the metal bellows at the ends. The continuous load capacity is 15 mA R. M. S., but for short periods the load may be increased, for example to 75 mA R. M. S. for a service period of half an hour. The valves can cope with reverse voltages up to 200 kV peak value. It is possible to obtain a direct voltage of 180 kV and a direct current of 10 mA continuously with two such valves and two capacitors in a Delon circuit, with a 70 kV transformer.

Various types of rectifier can be built up as desired with the aid of these large stacks together with transformers and capacitors. *Fig. 5* shows an example of a design of this type.

A considerably smaller unit can be obtained by building all the high-voltage parts together in a common oil tank with terminals for direct voltage only. This means that it is possible to reduce the number of high-voltage bushings and oil tanks required, for which reason an arrangement of this kind often pays. This is the case when the design cost can be divided up either by standardisation or the manufacture of several units.

Normally, a large number of operating and control devices is required for a high-voltage rectifier. These may all be suitably placed in a special control cabinet so that the oil tanks only contain the high-voltage parts which do not need to be accessible for adjustment.



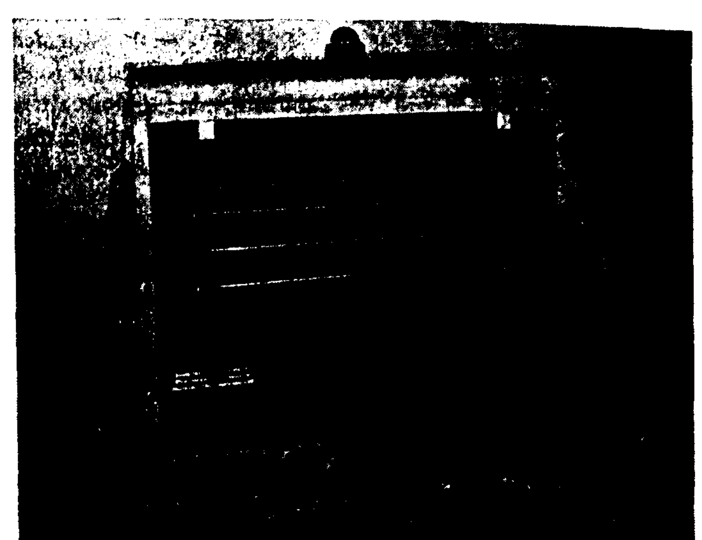


Fig. 6. Rectifier type RIPA for voltage testing with a direct voltage of 10kV. (43873, 43874)

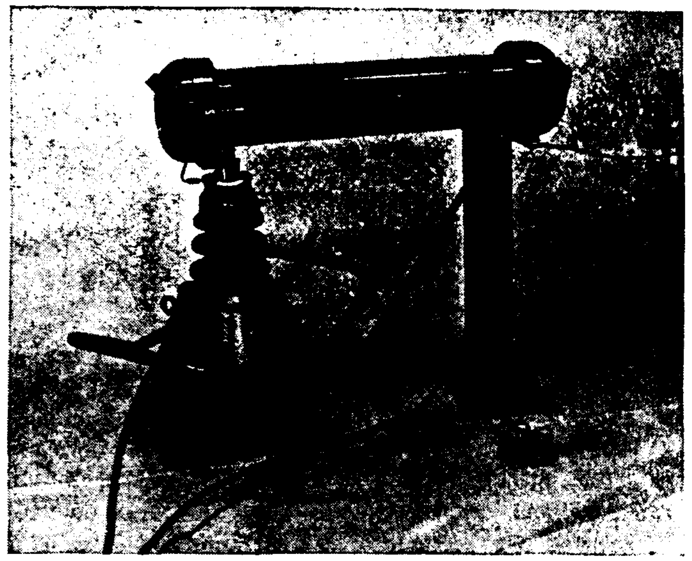


Fig. 7. Rectifier RVPA for voltage testing with a direct voltage of 75 kV. The selenium valve is supported by the high-voltage transformer (to the left) and the measuring series resistor (to the right). The high-voltage terminal can be seen at the top to the right and, in the picture, is earthed with the earthing gear of the rectifier. At the bottom, to the right, the clamp for the earth connection of the rectifier can be seen. (43043)

EXAMPLES OF APPLICATION

Rectifiers for voltage testing

When carrying out voltage tests on equipment with solid insulation material, for example, cables, capacitors, and generators, direct voltage has considerable advantages over alternating voltage.

The output required when testing with direct voltage is very small as compared with the output required when using alternating voltage, particularly in those cases where the capacitance of the objects being tested is large. If the inductance is distributed along the tested object, as in a long cable or a generator winding, the voltage can vary at different points if alternating voltage is used.

In the case of alternating voltage, the dielectric strength is a function of the stress time, and the relationship voltage—time is a falling curve. Thus, at a higher voltage, breakdown occurs more quickly than at a lower voltage. This implies that if the alternating voltage is high enough to show up weak insulation, permanent changes also occur in the unaffected parts of the insulation, which may be noted in increased dielectric losses, and, above all, in reduced life.

These disadvantages are not present in the case of direct voltage since the relationship voltage-time is largely a horizontal line and not a falling curve (plotted with the time as abscissa) as is the case with alternating voltage. This means that it is possible to test with a voltage which is immediately below the breakdown limit without reducing the length of life. The insulation material is not affected by the voltage until breakdown or a leakage current occurs at weak points.

New cables, therefore, are usually tested with direct voltage, in which case a direct voltage equal to the impulse voltage stipulated for the insulation class in question is applied for 1 minute.

Since testing with direct voltage does not cause the insulating material to deteriorate, direct voltage is also used for the regular checking of the state of insulation of installations. By measuring the leakage current it is then possible to ascertain whether the insulation is gradually deteriorating.

ASEA manufacture two standard types of rectifier for testing with direct voltage which are intended for different voltage ranges.

The smaller type has the designation RIPA 10 and

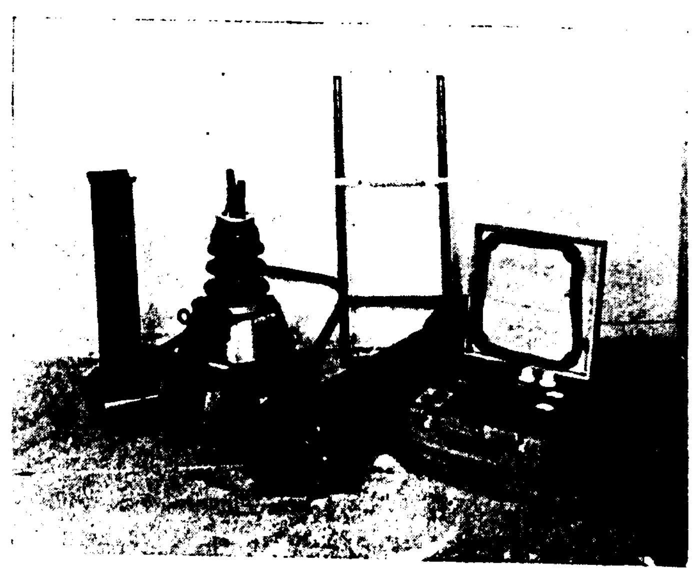


Fig. 8. Rectifier RVPA dismantled for transport. To the left, the series resistor with earthing gear can be seen, next to it the high-voltage transformer with signal lamp, lying on the floor the selenium stack and further to the right the control box. The base frame which is used when the foundation is uneven can be seen in the background. (43044)

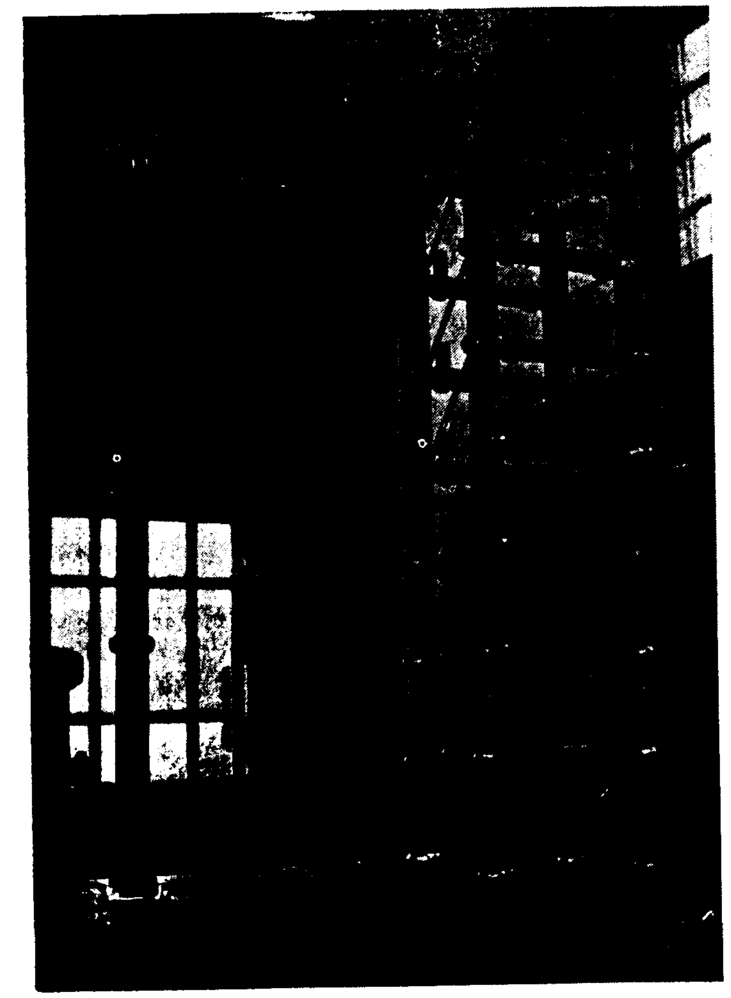


Fig. 9. Cascade rectifier for a direct voltage of 1200kV for testing cables and capacitors. (44389)

gives a direct voltage of up to 11 kV, while the larger type RVPA 75 gives 80 kV.

The rectifier RIPA 10, which can be seen in *fig. 6*, is built into a portable case. The voltage can be adjusted continuously within the range 0—10 kV by means of a switch for coarse adjustment and a resistor for fine adjustment. A smoothing capacitor of 0.06 uF is built into the rectifier.

An R. M. S. current of 10 mA can be taken out continuously, while up to 30 mA can be taken out for short periods. If this current is exceeded, the rectifier is protected by a fuse, and a number of spare fuses accompany the rectifier in a built-in case.

The direct voltage is measured on the high-voltage side by means of a series resistor and micro-ammeter, and the direct current is measured by means of a milliammeter at the earthed terminal of the transformer. The instruments are arranged in the panel and are easy to read.

A red lamp indicates that the rectifier is in operation. On the panel there is also a switch for various supply voltages.

There is also a high-voltage terminal for A. C. testing, where voltages up to 8 kV can be obtained.

The rectifier is mainly used for testing low-voltage installations, cables, and capacitors.

The rectifier RVPA 75 is intended for the testing of cables in distribution networks. Cables with a rated voltage of 10 kV are usually tested with 75 kV, and the rectifier gives a maximum voltage of 80 kV.

The rectifier consists of parts which can rapidly be put together on the site. *Fig. 7* shows the rectifier assembled and *fig. 8* shows the various parts. When assembling, the transformer and the series resistor are first placed on the floor, or on the frame if the foundation is uneven. The stack is placed over them and its connections are plugged in. Then, the leads from the control cabinet to the transformer and the series resistor are connected up, whereupon the rectifier is ready for use. Each part is fitted with carrying handles and can easily be carried by two men.

In the control cabinet, there is a variable transformer for setting the voltage, instruments for measuring the direct voltage, direct current and supply current, and over-load protection.

The ripple factor is not usually allowed to exceed 5 per cent on testing. With a load capacitance of 0.1 uF, which corresponds to about 500 yards of cable, the ripple factor does not amount to more than 2 per cent at 75 kV and 30 mA. A ripple factor above 5 per cent only occurs when the cables are very short, and in these cases it is possible to supplement the equipment with a suitable capacitor, for example with ASEA capacitor CTOA 22 of 0.1 uF.

A current of 10 mA can be taken out continuously, and 100 mA for up to 1 minute. The latter performance is of great importance since it makes it possible to break down the insulation at a faulty point sufficiently to be able to locate the fault by measurement.

The high-voltage transformer can be used alone for alternating voltage testing and then gives an R. M. S. value up to 60 kV.

If higher voltages are required for testing, use may suitably be made of a voltage-doubling, or cascade, circuit. *Fig. 9* shows a cascade rectifier for 1200 kV, 10 mA, operation being, in principle, the same as for RVPA 75. Naturally, because of its high voltage, the rectifier requires a great deal of space, but it can easily be dismantled and packed into a very much smaller space. This has proved to be of value in the case of tests on completed high-voltage installations.

Rectifiers for electrostatic precipitators

One of the larger ranges of use of high-voltage rectifiers is the operation of electrostatic precipitators. Voltages between 15 and 70 kV and currents between 10 mA and 0.4 A are found, and these ranges are the most suitable for high-voltage selenium rectifiers. The service conditions are often very unstable, with frequent flash-overs in the precipitator, but because of the great capacity of the oil to absorb heat the selenium plates withstand such over-loads without difficulty.

Different types of gas and dust give very different service conditions, and the most favourable rectifier for every purpose can be obtained by means of various automatic control devices.

If the composition and dust content of the gas always remains the same, thus ensuring steady service conditions, only one certain voltage and current is required. If the supply network has a fairly constant voltage, no automatic devices are normally required. However, it is necessary to be able to vary the voltage within certain limits, in order to obtain the right voltage empirically and to be able to adapt the voltage to gradual changes in the service conditions. The high-voltage transformer and rectifier valve are then both incorporated in an oil tank with only one high-voltage terminal, as *fig. 10* shows. Then, a

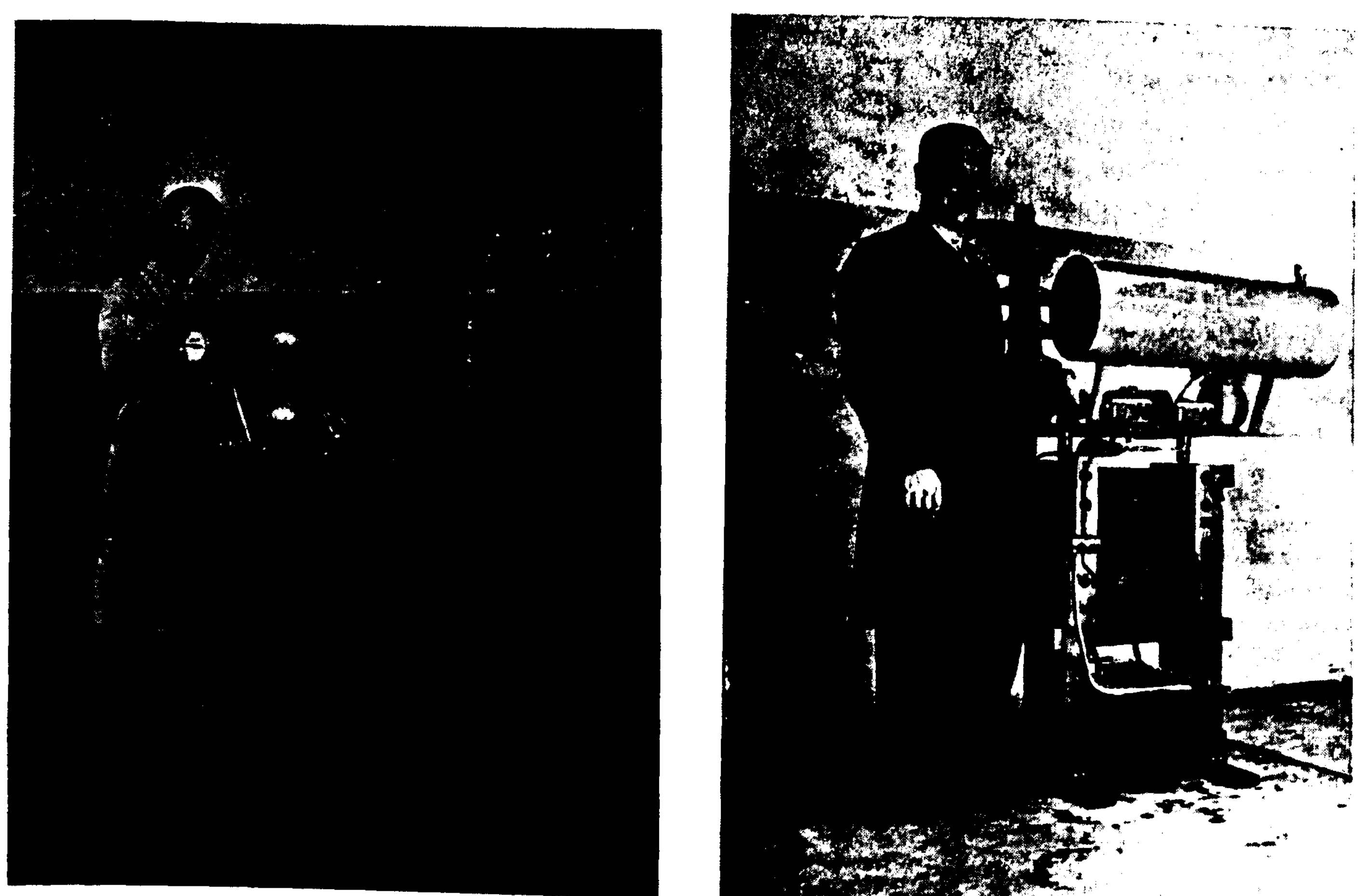


Fig. 10. Oil-insulated rectifier for electrostatic precipitators, to the left closed, to the right open. The selenium stacks are at the bottom and the transformer at the top. (43535, 43540)

regulating transformer, of the sliding-contact type for small outputs and of the tap-changer type for larger outputs, is set up in a control cabinet.

The characteristic of a rectifier of this type would be, in principle, as shown in *fig. 11*. Thus, the voltage drops as the current increases, but this has no significance when the service conditions are unchanged. The direct voltage is directly proportional to the supply voltage and, before deciding to adopt this system, a check must be made to see that the variations in the supply voltage are so small that they will not hazard steady operating conditions.

If the composition of the gas varies, automatic control should be introduced. This is most suitably done by means of a *transductor* which is placed in the control cabinet. The mode of operation of the transductor in the case of automatic control has recently been described in ASEA Journal 27 (1955), 5—6, pp. 78—84. With transductor control, two basically different characteristic curves can be obtained, as shown in *figs. 12* and *13*. The system as shown in fig. 12 is called current control, and the system as shown in fig. 13 is called avostat control.

Current control as in fig. 12 implies that a certain current is forced through the precipitator, whereupon the voltage assumes the value necessary in order to obtain this current. Thus, the voltage will vary.

Avostat control implies that both the current and the voltage can remain constant, one at a time. Normally, a rectifier of this type works within the range for constant voltage. This voltage, which is independent of the supply voltage, is so chosen that it is slightly lower than the flash-over voltage of the precipitator. The current, which can vary considerably, does not then affect the voltage until it becomes so high that the bend in the curve is passed and the region of constant current entered, where the voltage sinks rapidly. By this means the current is limited, so that the rectifier is protected against lengthy overloading, and the arcs which are caused by flash-over in the precipitator are rapidly extinguished. As mentioned above, such flash-overs are very usual in this type of service.

Rectifiers for electrostatic precipitators are often designed for single-phase operation so that it is possible deliberately to obtain a pulsating voltage, and, in the case of avostat control, to keep the peak value of the latter constant. The object of this arrangement

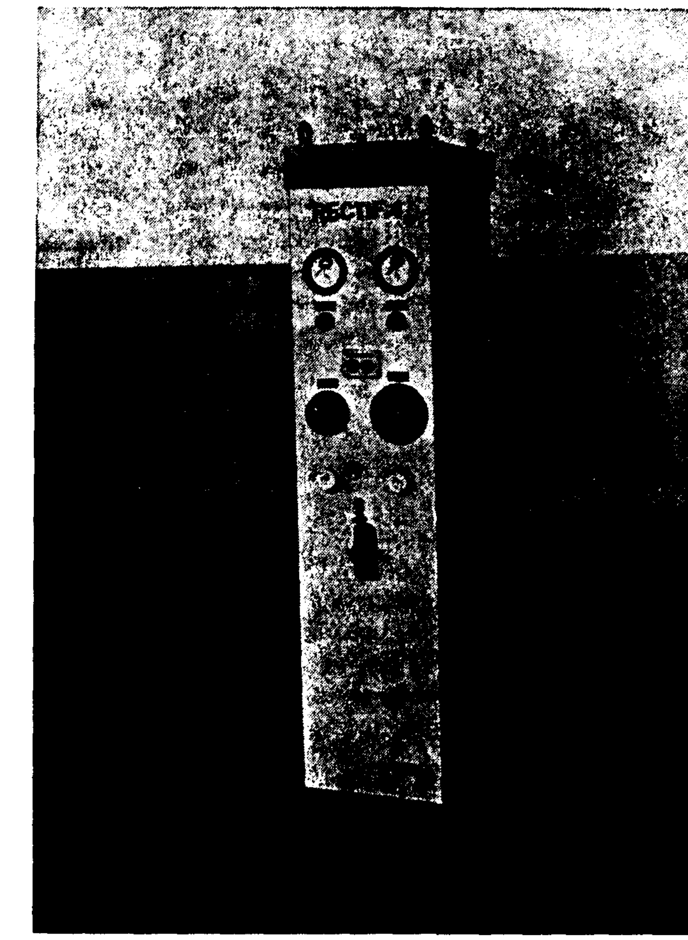


Fig. 14. Control cabinet for avostat-controlled rectifier for electrostatic precipitators. The cabinet contains operating devices, protective relays and control equipment. (43536)

is that the "voltage crests" should give good ionisation in the precipitator while the frequent flash-overs are extinguished in the "voltage troughs". However, a pre-requisite, if this effect is to be obtained, is that the capacitance of the load should be so low that smoothing is insignificant. The capacitance of the precipitator itself may be considerable, and if there is a high-voltage cable between the rectifier and the precipitator it is not possible to rely on obtaining the intended effect. Further, great capacitance gives powerful flash-overs and thus makes unsteady service even unsteadier, for which reason direct connection with a bare conductor between the rectifier and the precipitator is to be recommended.

In order to reduce the amount of supervision needed, a number of automatic control devices can be introduced. On the types of rectifier without

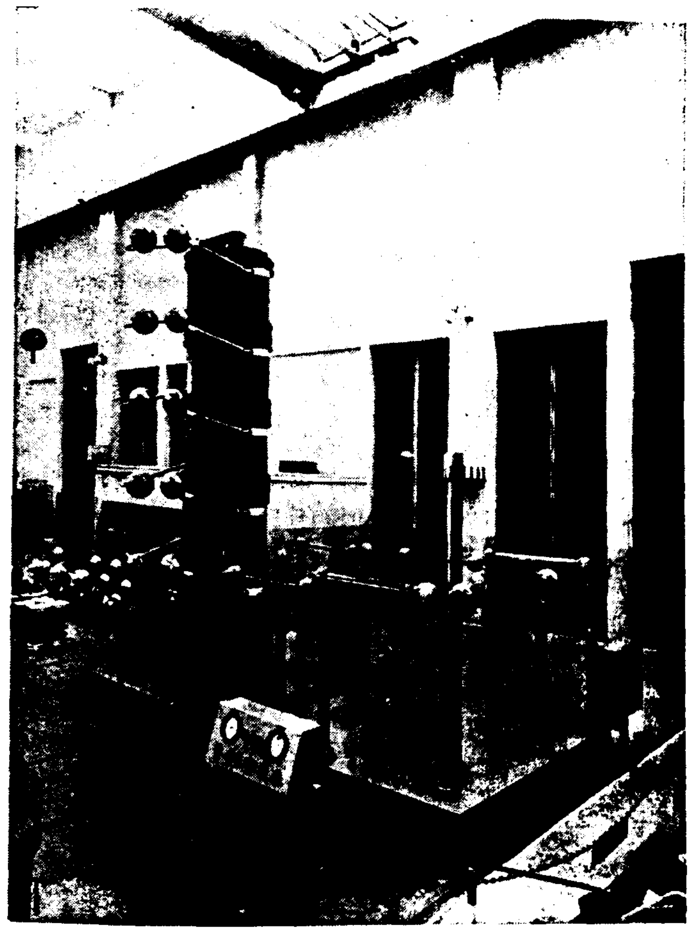


Fig. 15. Selenium stacks RYAB for supplying an impulse generator for high-voltage testing. (43533)

automatic control an inverse time-lag relay can suitably be used as over-load protection, and, in the transductor-controlled types, a time-lag undervoltage relay connected to the primary side of the high-voltage transformer. Since the faults are usually transient, for example bridging by dust particles, automatic reclosing should be employed.

If the flash-over limit varies greatly in a precipitator because of the varying composition of the gas, the voltage of the rectifier can be automatically adjusted by means of specially-designed motor operating gear which slowly turns the voltage-setting wheel so that the voltage increases. When flash-over occurs, the motor stops and if the flash-overs recur frequently it is automatically reversed and lowers the voltage. The current can vary freely at each voltage level. A device of this kind is of great value since it is possible continually to maintain the voltage which gives the best particle precipitation without constant supervision of the rectifier.

Fig. 14 shows the control cabinet, which also contains the control equipment for an avostat controlled rectifier. This cabinet serves a high-voltage rectifier as shown in fig. 10.

A rectifier consisting of a high-voltage part as in fig. 10 and a control part as in fig. 14, can be adapted to several various purposes without being altered extensively. Bearing in mind the character of the precipitator and the gas, the most suitable plant can be planned by making use of experience gained in plants which are already in service.

Miscellaneous uses

In addition to the above-mentioned spheres of use there are a great number of others where the high voltage selenium rectifier is suitable and has been used with success. An especially interesting sphere is the charging of capacitors in impulse voltage generators. *Fig. 15* shows a plant of this kind in which standard stacks RYAB have been used. The great overload capacity is especially useful here. The consumption of current is very great during the actual charging interval which lasts for several seconds, but the intervals between these operations are considerably longer. In addition, a plant of this kind is only operated for a short period at a time. Under these conditions, it is possible to obtain current peaks of up to 1 A with the RYAB stack.

High direct voltages have been taken into use in industry for several purposes amongst which mention can be made of the electro-static draining of dip painted objects, electro-static paint spraying and the coating of sandpaper. A similar use of direct voltage is to be seen in the so-called electro-inhalatorium in which certain substances are finely diffused by means of high voltage so that when they are breathed in they penetrate deep into the lungs.

For these and similar purposes it is possible to build up with the available standard stacks, without the need for comprehensive special manufacturing equipments which are adapted to the needs of the customer. These valves are also supplied separately with all the information required for designing the equipment.

The Indian Standard for Rolled Steel Beams

By T. V. Joseph, B.E., IRSE.,
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THE publication in September 1957 of IS : 808—1957 Specification for Rolled Steel Beam, Channel and Angle Sections, marks the completion of the most important part of the Steel Economy Programme of the Indian Standards Institution. Over three years of continuous study in India and abroad and the deliberations at numerous sittings of committees, panels and study groups have contributed to this work. In this paper, is briefly described the more important characteristics of the Indian Standard Beams and the considerations which governed the design of these sections.

In 1950, while considering the requirements and availability of steel for the First Five Year Plan, the Planning Commission of India set up a special Panel to evolve a programme of work for increasing the efficiency in the production and use of steel in India. An important finding of this Panel, whose work led to the inauguration of the Steel Economy Programme of the ISI, was that the production standards in India for structural sections had not kept pace with the progressive improvements in rolling mill design and technique, and the better understanding of the principles and application of shape engineering. The Panel considered that redesign of the structural sections could result in saving in tonnage of steel used, as well as in overall economy. The detailed work on the redesign and standardization of higher efficiency sections was initiated by the ISI on the basis of this recommendation of the Planning Commission of India and at the request of the Government.

PROCEDURE FOR INVESTIGATION

In formulating the standards for rolled steel beams, the following factors have been taken into consideration :

(1) Present production standards in India ;

(2) National standards and competitive standards introduced by the Industry in other countries ;

(3) Attempts made in other countries towards improvement of standards for beam sections;

(4) Aspect of efficiency in use of the sections, analysis of the factors which affect efficiency and the extent to which it is possible to improve efficiency ; and

(5) Limitations and the capabilities of existing mills and of the mills to be installed in India, and application of these limits in the formulation of the standards.

PRODUCTION STANDARDS IN INDIA

The production of steel beams in India has been generally based on British Standards. But, due to the small overall tonnage of production, rationalization on a somewhat arbitrary basis had been imposed. Against 40 beam section specified in B. S. 4 : 1932 and 31 sections shown in the sale lists of the Indian mills, only 19 sections have been shown as rationalized sections. There is no indigenous production of Junior beams, Light beams, Wide Flange beams or Column Sections H-beams.

STANDARDS OF OTHER COUNTRIES

A study of the national and competitive industrial standards of various countries indicated that while the national standards of most countries were, in general, similar to the British Standards, individual steel producers had improved their sections and have for many years been producing higher efficiency sections.

IMPROVEMENT TO STANDARDS IN OTHER COUNTRIES

In general it was observed that the improvements in beam sections effected in other countries have been mainly through the following methods :

(1) reduction in the web thickness,

(2) increase in the width of flanges,

(3) provision of parallel flanges or reduction in the slope of flanges,

(4) rationalization in the number of sections

produced and arrangement of sections in more systematic series, and

(5) general reduction of weight.

ASPECT OF EFFICIENCY IN USE

A beam section is used as a flexural member, compression member or tension member. The 'efficiency' of the section is its load carrying capacity per unit area of cross-section. The ability of a beam to resist and transfer the loads or stresses is mainly dependant on :

(a) section modulus for bending,

(b) moment of inertia for resistance to deflection,

(c) cross-sectional area for tension and compression, and

(d) radii of gyration for compression.

In addition, the component elements of the beam (i. e. web and flange) should be so proportioned as to have sufficient rigidity or resistance against :

(a) lateral instability of the compression flange,

(b) secondary failure due to local buckling of the individual component elements, and

(c) failure of the web due to insufficient shear carrying capacity.

EFFECT OF THE WEB OF THE BEAM

Except for the addition to the available cross sectional area, the material in the web contributes very little to the load carrying properties of a beam section, other than to its resistance in shear. The section moduli, radii of gyration, moments of inertia or lateral stability of the section are affected very little by any change in the thickness of the web.

Experience has shown that it is seldom that the shear capacity of the web as at present rolled in India is fully utilized in actual designs. The thicknesses of web now produced are also found to be excessive from the point of view of safety against secondary failure in buckling or crushing.

It was found that generally speaking, there is scope for improving the efficiency of beam sections by a reduction of the web thickness. Though the theoretical limits to which such reduction is possible can be fixed from the point of view of use, it is usually found that such limits lead to thicknesses so small that rolling mills are not capable of producing them. It is found that in the design of the beam sections, the minimum thicknesses for webs are usually decided by the capabilities and limitations of the rolling mills for which the beams are being designed.

EFFECT OF THE FLANGES OF THE BEAMS

Variations in the cross-sectional area of the flanges, on the otherhand, result in a corresponding variation in all the load carrying propeities of the beam. For a beam of given depth and web thickness, the sectional area of the web a_w being constant, the section modulus Z increases as the sectional area of the flanges a_f increases. But the increase in section modulus Z for unit increase in the sectional area a_f of the flanges is not the same for all values of a_f. The rate of increase of Z/a continues to increase only until a particular optimum value is reached for the factor a_f/a_w. For values of a_f/a_w larger than this optimum value the rate of increase reduces progressively, finally becoming negative. For the types of beam sections under consideration the optimum value of a_f/a_w at which the rate of increase is a maximum, is found to lie in the range of 0.75 to 1.0, the exact value depending on the depth, width of flange and thickness of web of the beam under consideration.

For an individual beam of given depth, values of a_f/a_w higher than the optimum give increased values for Z/a, but for an efficiently designed series of sections, wherein the minimum web thicknesses adopted are the same or increase at a uniform rate as the sections increase in depth it is more advantageous to utilize the extra material in a deeper section having an optimum value of a_f/a_w. In a series of beams, it is, therefore, advantageous to maintain the values of a_f/a_w within the optimum range.

The analysis described above establishes a theoretical procedure for obtaining most efficient values for a_f. But there are certain difficulties in approaching these optimums for a practical series. The thicknesses of the flange, obtained with the optimum values of a_f/a_w are in many cases too small to permit convenient production in the mills. The sections derived with optimum values are very light with the result that even with the largest size beams producible in the ordinary mills, the full requirement of sectional areas and moduli of section cannot be covered. Furthermore, beams designed with optimum values for a_f/a_w do not have their weights or section moduli arranged in a satisfactory progression. As pointed out later, it is more important to obtain a suitable gradation of weights and section moduli for a series than to obtain the increased efficiency possible through maintaining the a_f/a_w values within the optimum range. In order to cover the full ranges of depth of sections and section moduli required without increasing the number of sections unduly, the increase in depths of consecutive sections have to be kept relatively large. To meet rolling requirements, the increased depths, require correspondingly larger minimum web thicknesses also. It is, therefore, frequently found that in order to maintain a suitable gradation in weights and section moduli, additional material has to be placed in the flanges, increasing the a_f/a_w ratio above its optimum value.

In the design of the beam series, maintenance of low values of web thicknesses and suitable gradation of weights and section moduli have, therefore, been given more importance than the aspect of flange area.

In the case of an unrestrained flexural member, the permissible stresses in the compression flange depend on the width of flange or the radius of gyration of the section on the Y—Y axis. It is, therefore, advantageous in such cases to have the material in the flange distributed in as wide a flange as possible. The wide flange section is advantageous as a compression member also since the radius of gyration on the Y—Y axis depends directly on the width of flange.

GRADATION OF WEIGHTS IN THE SERIES

The requirements of the users are for an unlimited variety of section moduli. This unlimited variety of demand has necessarily to be met by a limited number of standard sections. This position leads to certain amount of wastage which is unavoidable. The inevitable wastage on this account can be reduced by increasing the number of sections and also by arranging the sections in systematically graded series. This is obviously a limit up to which the number of standard sections can be increased, and, therefore, an important consideration in the design of the standard beam series is that of the gradation of the beams in the series.

If it were possible to forecast the requirements of section moduli or sectional area of sections in the different ranges covered by the beam series, the sections could be arranged in the series in such a way that the total excess of material used because of the unavailability of intermediate sections, would be reduced to a minimum. Such a forecast of future demand could be made if reliable information regarding past consumption were available and the pattern of use and the type of sections available, in the past and the future, remain the same. These conditions are not all satisfied in India.

In the past, only one series of sections known as normal beams were available in India. With the installation of increased production capacity in India, junior beams, light beams and wide flange beams would also be available to users. The pattern of use in the future for building and other industrial purposes would also be different. It was, therefore, felt that a statistical study could not be entirely depended upon for forecasting the future trend of demand. Under this condition of uncertain future demand, it was decided that the most satisfactory gradation for the sections in the series would be that derived from general mathematical considerations. It is generally accepted that when an uncertain pattern of demand is required to be met by a *limited number of products, the most satisfactory arrangement is obtained when the basic properties of the products are graded to follow a geometric progression. In the case of hot rolled sections, the weight of the section has been selected as the basic property to be graded. It was also noted that in a series of beams where the weights are arranged in geometric progression and the depths, flange widths and web* and flange thicknesses are also graded to a pattern, the section moduli also follow closely a geometric progression.

It may be mentioned that a statistical analysis of the data regarding production and use of beam sections in India, also confirmed that the gradation according to a geometric progression would be satisfactory. The production data for a period of 14 years up to 1954 was considered. Very wide variations were found in the percentage production of different sections. It was evident that all the sections in the series were not equally efficient nor was the distribution of sections in the series rational. But, it was found that for each range of section moduli, the tonnage demand of beams, expressed as a percentage of the total production of beams, remain fairly constant from period to period and it was possible to ascertain the general trend of demand of section moduli over the whole range covered by the beams produced in India. Statistical analysis of the pattern of demand during the 14 years preceding 1954 has confirmed that the most efficient arrangement of weights that could be established would be one following a geometric progression.

PRODUCTION ASPECTS

The present equipment of the existing mills in India is capable of producing only I-beams, generally known as normal beams, to a maximum depth of 600 mm. (or 24 in.) and width of flange of 190 mm. (or 7½ in.). When the new mills also start operation, it is expected that the existing equipment will be required to handle only beams to a maximum depth of 450 mm. (or 18 in.). According to the present plans, beams are to be produced in India through the following mills:

(a) Tata Iron & Steel Co. Ltd., (TISCO), in their existing mills and also in their new medium and light structural mill;

(b) Indian Iron & Steel Co. Ltd. (IISCO), in their existing mills;

(c) Bhilai Steel Plant *(Government) in their rail and structural mill;*

(d) Durgapur Steel Plant (Government) in their medium and light structural mill.

The existing mills of TISCO and IISCO can produce beams with a slope of flange of about 8°. The web thickness, width of flange and thickness of flange of the beams to be produced in these mills will have to conform to the characteristics of the mills.

The new medium and light structural mill being installed at TISCO can produce light-weight beams up to a maximum depth of 200 mm. (or 8 in.) and width of flange of 100 mm. (or 4 in.). This mill will be able to produce ' parallel flange ' beams with a slope of 1½°.

The Bhilai Steel Plant can produce beams of depths of 200 mm. (or 8 in.) to 600 mm. (or 24 in.) having a maximum width of flange up to 250 mm. (or 10 in.). The Durgapur Steel Plant will be able to produce beam sections up to a maximum depth of 200 mm. (or 8 in.).

The expansion of the existing mills and the installation of new mills would by 1959 or 1960 make available in India additional equipment suitable for the production of light beams up to a maximum depth of 600 mm. (or 24 in.), Junior beams up to a depth of 200 mm. (or 8 in.), wide Flange Beams and Column Sections up to a depth of 600 mm. (or 24 in.) and maximum width of flange of 250 mm. (or 10 in.).

INDIAN STANDARD SERIES OF BEAMS

Indian Standard Beams are covered by the following series:

(a) Indian Standard Junior Beams (ISJB),

(b) Indian Standard Light Beams (ISLB),

(c) Indian Standard Medium Weight Beams (ISMB),

(d) Indian Standard Wide Flange Beams (ISWB), and

(e) Indian Standard Column Sections—H-Beams (ISHB).

The Indian Standard Junior Beams (ISJB) are designed to meet the special needs of light-weight constructions. The light beams (ISLB), medium weight beams (ISMB) and wide flange beams (ISWB) *are meant to cover the common structural and general engineering requirements for beams. They are designed essentially to be used as flexural members. The Light Beams may not be suitable for conditions where heavy loadings occur as in the case of heavy industrial buildings. The Medium Weight* Beams and the Wide Flange Beams have many common fields of use.

The dimensional properties of the beam sections have been arrived at on the following basis:

(a) *Depth of Beam*—The gradation for the depths in the metric system could have been arranged either in 10 and 20 mm. or in 25 and 50 mm. The former arrangement was found to lead to too large a number of beams. Further the latter arrangement of 25 and 50 mm. was considered to be more acceptable in India since the gradations would be close to the present inch gradations. On this basis the gradation in depths have been arranged in 25 and 50 mm.

(b) *Width of Flange—* The widths of flanges have been kept as large as possible, consistent with the capacity of the mills under consideration. A 5 mm. module has been used in grading the widths.

(c) *Web Thickness—* The advantage in keeping the web thickness as small as possible consistent with end use requirements and mill limitations has been kept in view. In the heavier series of beams, where section moduli values are larger, thicker webs have been provided.

(d) *Thickness of Flange—* The most efficient series of beams as regards the relationship between section moduli and weights is obtained when low values are adopted for the ratio area of flange to area of web. While an attempt has been made to maintain low values for ratio area of flange to area of web, consistent with the limitations of the mills, departures had to be made in order to adjust the weights and section moduli to the required gradations.

(e) *Gradation of Weights—* Except for the Indian Standard Junior Beams (ISJB) which are limited in number and use, the gradation of weights of the sections in the other four series (i. e. ISLB, ISMB, ISWB and ISHB) has been adjusted to bring them close to a geometric progression. However, in the ranges of smaller weights and section moduli, the progression of weights for the individual series proceed at a larger percentage variation than for the remainder of the series. This was necessary to avoid getting too many sections in the lower ranges. It was further desirable to adopt this procedure since the four individual series and the additional junior beam series altogether provide an adequate choice of weights and section moduli especially in the lower ranges.

It is also important to note that the ISMB and ISWB series which are meant to meet the major normal demand for beam sections, can be integrated to form one series in geometric progression in both weight and section moduli. In the case of ISHB series more than one weight of section provide for each size of beam, is considered an advantage. The sections of different weights in each size, are meant for production from one set of rolls and the thicknesses of webs and flanges are adjusted to suit this purpose.

COMPARATIVE STUDY OF EFFICIENCY

The charts Fig. 1 and Fig. 2 may be used for a comparison of the efficiency of the Indian Standard Beams as against the sections at present produced in India. The chart Fig. 1 compares the ISLB with the beams produced now and the Chart Fig. 2 compares the combined series of ISMB and ISWB, with the present production. In both the charts only the more efficient of the latter beams have been connected by the stepped lines. The other sections which are less efficient have also been shown as points on the charts.

It is seen from these charts that for practically all section moduli requirements, the Indian Standard series of beams make available a lighter section than the beams existing until now. The percentage saving in weight for any particular section moduli value could also be easily ascertained. The ISLB series by itself offers large economies in weight. In cases where conditions of loading and other features do not permit the use of the ISLB series, the ISMB or ISWB series may have to be used. It is seen that in this case also the economies available are substantial though not to the same extent as in the case of ISLB series. In the case of the ISWB series, the increased economy available because of the wider flanges cannot be readily seen from the chart.

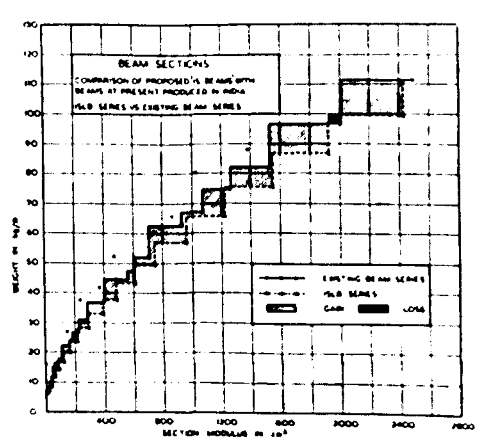


Fig. 1. Graphical illustration showing savings in material by using ISLB series in place of the existing beam series.

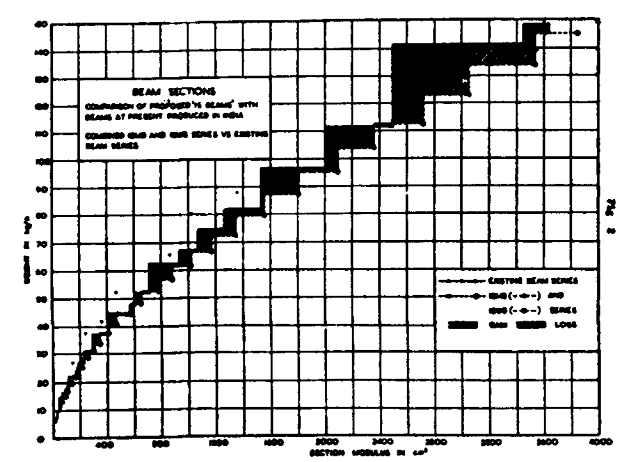


Fig. 2. Graphical illustration showing savings in material by using ISMB and ISWB series in place of the existing beam series.

Using the charts Fig. 1 and Fig. 2, it is possible to estimate in terms of tons and rupees the annual savings which should result from the introduction of the Indian Standard series of beams, if the requirements of section moduli in the different ranges and of linear feet consumption for each section modulus are available.

CORROSION

While formulating standards on hot rolled steel sections, consideration was also given to the aspect of corrosion. A view sometimes expressed by structural engineers is that steel sections should have enough material incorporated in them to provide a margin of wastage due to corrosion. It was considered that with the increased knowledge of various aspects of corrosion and corrosion prevention, there should be no difficulty in protecting steel structures to the extent necessary to ensure that the sectional area of metal originally provided in structural members continues to be available during the full life period of the structure. It is true that even now there are cases where the maintenance of structures is not receiving the attention which it deserves. But, the remedy for this laxity on the part of a few engineers, lies in the tightening up of inspection and maintenance procedure rather than through the wastage of steel to cover corrosion permitted by such laxity. It was appreciated that there are occasions and conditions of use where complete and continued protection against corrosion cannot be assured. Such cases may require the use of heavier sections then are indicated by strength considerations.

CONCLUSION

In accordance with the decision of the Government to adopt the metric system of weights and measures in India, the Indian Standards for beams use the metric system exclusively. The changeover to a new system of weights and measures would anyhow have required modifications to production standards affecting both producers and consumers. The introduction of the new and improved standards for structural sections, coinciding as it does with the implementation of the metric system is, therefore, most opportune.

In countries where a highly developed steel industry already exist, modifications to production standards require the co-ordination and co-operation of a large number of steel producers. Their natural resistance to changes in their equipment and methods and economics of production have to be overcome. India fortunately is at present passing through a period when conditions are opportune for the implementation of a changeover to new and improved standards for structural sections. The present production of steel in India is small when compared to her needs and is practically all from two mills. The managements of the existing mills in India have indicated their willingness to co-operate in any scheme which is aimed at improving the production standards. In the next few years, the production of steel in India will be more than quadrupled. This increase will be through the installation of new mills and through the renovation and expansion of the existing mills. The new steel mills in India being set up and controlled by the Government, are naturally of modern design and it is possible to introduce many improvements in the existing mills also at the time of their renovation.

The work of the ISI in the field of standards relating to the production and use of steel indicate that producers and consumers have large benefits to derive through the formulation of improved standards for steel products. The beam sections according to the Indian Standards have increased efficiency characteristics which would yield 5 to 15 percent saving in the tonnage of material required in particular applications. The economies possible through the implementation of these standards would

(Continued on page 30)

FINNISH CELLULOSE

By

A Special Correspondent

EVER since the invention in the middle of the 19th century of the process of making paper from wood Finland has been with the leading producers of cellulose and mechanical pulp. The first mechanical pulp mill was established in Finland 98 years ago and the first cellulose mill began operations in 1876. The reasons for this progress are obvious. The tree species growing in Finland are very suitable raw material for paper-making and, secondly, Finland has the water for timber floating and for the hydroelectric power needed by industry.

Finland's cellulose and mechanical pulp industry still holds a prominent position today. It has expanded considerably and its trading connections extend throughout the world. In addition to this expansion outwards, the industry has broadened inwardly. There is hardly a single village in Finland unaffected by the forest industry, and by the cellulose industry in particular, for timber is logged even in the farthest corners of the country.

Strong though its progress has always been in Finland, the expansion of the cellulose industry has been exceptionally powerful in the present decade.

The Finnish cellulose mills are up-to-date. This one, situated in the town of Oulu, produces over 150 000 tons of sulphate cellulose annually.

The intensive expansion in the 1950s is best illustrated by the following figures of productive capacity: for the sulphite cellulose industry at the turn of 1949/1950 it was about 900 000 tons per annum, in 1956/1957 around 1100 000 tons; for the sulphate cellulose industry it has grown from about 550 000 tons per annum to roughly 950 000 tons in the same period. Hence the productive capacity of the cellulose industry as a whole increased in these six years by some 50 per cent. The following table sets out for easy reference the quantities produced and exported.

	1950		*1956*	
	Production	Exports	Production	Exports
Sulphite cellulose	717,400	513,340	993,800	678,812
—Rayon cellulose	65,000	42,840	160,300	137,436
—Bleached cellulose	160,300	113,786	198,000	98,021
—Unbleached cellulose	492,100	356,714	635,500	443,355
Sulphate cellulose	476,300	365,408	856,800	452,290
—Bleached	7,900	—	132,200	22,362
—Unbleached	468,400	365,408	724,600	429,928
Semi chemical pulp	—	—	8,300	—
Total ..	1,193,700	878,748	1,859,000	1,131,102

Production: according to the Finnish Cellulose Union
Exports: Official export figures

(Continued from page 29)

mean conservation of available resources and considerable savings in foreign exchange. The finalization and acceptance of the new Indian Standard for hot rolled steel sections has been possible only through the close co-operation and goodwill of various Government Agencies, the major steel mills and many steel design and fabrication organizations in the public and private sectors all over India.

There are 20 sulphite pulp mills in Finland. One of the many recently modernized mills is this in Jakobstad with an annual production of 70 000 tons.

There is a continuous research and quality controlling work going on in the laboratories of the cellulose industry.

This expansion has taken place solely through the enlarging and modernisation of existing plants. The number of the mills at the two points of time mentioned was identical: 20 sulphite cellulose mills and 9 sulphate cellulose mills. It can be taken, then, that at the beginning of the 1950s the average productive capacity of the sulphite cellulose mills was about 45 000 tons per annum and of the sulphate cellulose mills about 61 000 tons per annum. By 1956/1957 these averages had grown to 55 000 tons per annum for sulphite cellulose and 105 000 tons for sulphate cellulose. For anybody acquainted with this branch of industry these figures illustrate the really large scale of the production units of Finland's cellulose industry, especially of the sulphate cellulose industry. Indeed, Finland has the three largest cellulose mills in Europe today.

The following technical details may be of some interest. A total of 102 digesters, average volume 194 cu. m., are in operation in the sulphite cellulose industry. The largest digesters in use have a volume of 300 cu. m. In the sulphate cellulose industry the number of digesters is 64, average capacity 101 cu. m. The largest digesters are 160 cu. m. in volume. In addition, there are the digesters employed where the continuous sulphate cellulose cooking process is used. Progress is naturally observable not only in the cooking technique and the lye-circulation system of the digesters but also in their structural material. Stainless steel has now begun to invade also this field.

During the expansion process of the mills in the present decade their technical standard has also improved considerably. It has been possible to improve the economy of the sulphate cellulose cooking process via new heat recovery systems, by regenerating the lime needed in the process in lime sludge kilns and by recovering in electric filters the sulphate dust suspended in the exhaust gases. For sulphite cellulose, there has been progress specifically in the evaporation and burning of sulphite waste liquor. Many sulphite cellulose mills in Finland have already installed or are currently installing burning and evaporation plants. They will help to make the sulphite cellulose mills self-sufficient as regards heat. The cellulose bleaching capacity has also been increased continuously.

For all this very substantial expansion in Finland's cellulose industry during the 1950s, extensive facilities for further growth still exist. There is plenty of timber in Finland's forests. According to scientific surveys, Finnish forests will allow the doubling of cellulose industry production. This presupposes, however, the construction of new communications and improvement of the carrying capacity of the railways and floating channels. This is no fanciful thinking. As the world demand for paper continues to grow the strong, long-fibre timber of the conifers of the North will be a much sought-after commodity and Finland's cellulose producers will do their best to satisfy the demand. The development in Finland in the last few years is proof of earnest in this respect.

INDO-NORWEGIAN TRADE

The validity of the trade agreement between India and Norway, has been extended up to the end of December next. Under the agreement India will continue to export to Norway, inter alia, mica, iron and manganese ores, and light engineering goods. Among the commodities available for export from Norway to India are aluminium manufactures including aluminium boats, galvanised and black steel pipes, testing machines, welding equipment, machine tools and miscellaneous machinery.

New Driving Machinery for Rubber Mixers

By W. Bengtsson
Industrial Engineering Dept., Rolling Mill Section, Sweden.

In order to reduce the amount of space required for rubber mixers, ASEA have designed a special gear of symmetrical type with the driving motors attached to it by flanges. A simple method of running the mixers at half speed during the mixing period is to connect them in tandem.

THE raw material used for manufacturing car tyres, rubber mats, galoshes, *etc.*, to name only a few of the rubber products which play such an important role in our daily lives, is natural rubber which is supplied to the rubber factories in large bales. It is cut up into lumps weighing about 20 kg (40—50 lb.) which are then subjected to very severe treatment before they reach the degree of refinement required. It is interesting to note that natural rubber has, by no means, the elasticity which is normally associated with the word rubber. It is not until it has been processed and mixed with various chemicals that its elastic properties become apparent.

The first in a series of processing machines through which the natural rubber is passed during the refining process is the rubber mixer. Its task is to soften and prepare the rubber in such a way that it becomes possible to mix in the chemicals and to knead them into the mass so that it becomes completely homogeneous. In some cases, before the natural rubber goes into the mixer, it may be processed in a plasticator, which very much resembles a large mincing machine. When this machine is used, the processing time in the mixer can be reduced.

Previously, mixing was carried out in completely open rubber-mixing mills, that is to say, quite simply two horizontal, driven rolls lying alongside each other, and it is still thought that these mills give the best results. However, the processing time was long, and, furthermore, when soot came into use as the most important component, an open mill could not be used if the workshop was to be kept fairly clean. It was for this reason that the rubber mixer with an enclosed mixing chamber was designed.

The processing is done by two rotors of special design as shown in *fig. 1.* They are mechanically

Fig. 3. Driving machinery consisting of one motor of 400 h. p., 730 r/m, one motor of 800 h. p., 980 r/m, and a gear with ratios of 730/100 and 980/200 r/m, respectively (33633)

connected together via gear-wheels with a rather different number of teeth and therefore they rotate at slightly different speeds, which makes the kneading more effective. The processing time is divided up into a breaking-down period and a mixing period. The breaking-down of the lumps of raw rubber takes place first, and when the rubber has reached the desired consistency, suitable chemicals, such as soot, stearine, wood tar, *etc.* are added. During this latter period, it is of great importance that the speed of the rotors should not be excessive, since the temperature of the mass might then rise to unpermissible values. After processing, the mixing chamber is emptied by opening a slide at the bottom while the rolls are rotating. The material then normally falls direct on to a rubber mill for further treatment.

When using A. C. driving machinery with only

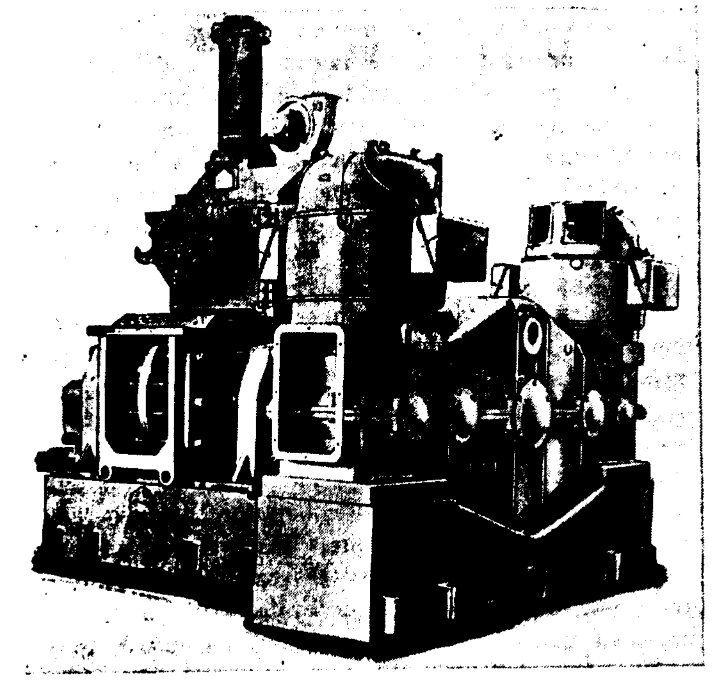


Fig. 4. Gearing type ULUZ with built-on motors. (45812)

one motor speed, the speed of the rotors is determined by the conditions during the mixing period. The speed should then be kept low, usually within the range 15—30 r/m. On the other hand, during the breaking-down period, higher speeds are desired in order to save time and may quite well go up to about 40 r/m. Thus, it is desirable that it should be possible to run the driving machinery at two different speeds, but continuous speed regulation of the driving motor is hardly necessary although it would, of course, be useful for the empirical determination of the optimum speeds. Another requirement is to reduce as far as possible the amount of space required for the driving equipment. An arrangement as in *fig. 2 a* with its double driving motors, one for each speed takes up a great deal of room. Further, the gearing is split up into two separate stages, one self-contained and the other of open design and built together with the mixer. It will be seen that the driving machinery takes up the greater amount of space.

The length of the machinery can be reduced by means of double pinion drive in the gearing, as will be seen from *fig. 2b* and also from the photograph in *fig. 3.* The gearing here is of symmetrical type with a pinion for each motor. The open gearing on the mixer itself is, however, still there and the length of the set is only reduced because the motors have been placed side by side instead of in tandem.

In order effectively to reduce the space requirements, ASEA have designed a special gear for rubber mixers, the appearance of which can be seen from *fig. 4.* The motors have been attached on top of the gearing by means of flanges, with their shafts running vertically. All the speed reduction from the motor speed to the low speed of rotation of the rotors, approximately 25 : 1, is provided by the gearing, thus allowing the open gearing on the mixer itself to be dispensed with. A sketch of the arrangement is shown in *fig. 2c.* A comparison between figs. 2a, 2b and 2c shows the amount of space which has been saved.

The gearing is of symmetrical type with one bevel part and two cylindrical gear stages. The arrangement of the gear-wheels is shown in *fig. 5.* The set is designed for a continuous output of 600 h. p. at 40 r/m and 300 h. p. at 20 r/m. The two speeds are obtained either by connecting the motors to the network in parallel in the normal way, or by connecting them in tandem. Thus, each motor can be designed for half the output necessary if one motor were being used for each speed. A further advantage is that, since the two motors work together at both low and high speeds, the symmetrical design of the gearing is utilised to the full. The large outgoing gear wheel can be made smaller than it would otherwise have to be, since the gear pressure is divided up over two pinions. The two pinions subject the outgoing shaft to a pure torque and its bearings are thus not exposed to any load arising from the tooth pressure.

Fig. 6 shows the arrangement of the complete

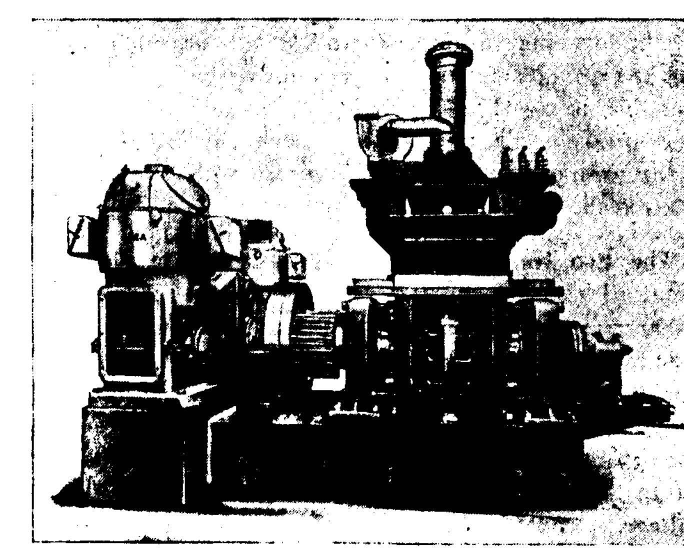


Fig. 6. 260 litre (9 cu. ft.) rubber mixer and driving machinery on a common base. (45813)

Fig. 8. Small mixer with gearing type ULUA for a maximum continuous output of 300 h. p. at 25 r/m. (44465)

mixer with its driving machinery. The mixer, which is manufactured by AB Abjorn Andersson, Svedala, Sweden, has a mixing chamber with a volume of 260 litres, (9 cu. ft.) and the two rotors are carried in roller bearings in separate bearing pedestals. In order to drive both the rotors they are connected together via a pair of gearwheels. One of these is shrunk direct on to the hub of the elastic coupling, and this too also helps to reduce the amount of space required. All the machinery, which weighs about 50 tons, is mounted on a common base which is placed on rubber pads on the site. This has contributed to the damping of any possible vibrations, and above all, to preventing these from affecting the surroundings.

The opening in the end wall of the gearing is the cooling-air inlet for the nearest motor, but it is also possible to cover this opening by means of a plate and to take in air from below through the foundation, if this arrangement would fit in better with the conditions at the place of erection.

The two secondary speeds, 20 and 40 r/m, correspond to the synchronous motor speeds 500 and 1,000 r/m, and the lower of these is achieved, as mentioned above, by connecting the motors in tandem. *Fig. 7* shows the electrical connection in simplified form. The two motors are quite normal, and exactly similar, slipring, three-phase induction motors. However, when selecting the secondary voltage, it must be borne in mind that the secondary winding of the one motor will have to excite the stator of the other motor when in tandem connection.

At high speed, the two motors are connected to the network individually in the normal way and work, in this case, as six-pole induction motors connected up mechanically via the gearing. Only one of the motors has a starting rheostat and is used for accelerating both motors. When full speed is reached the secondary side of the other motor is short-circuited.

In the case of tandem connection, motor 1 only is connected to the network and its sliprings to the primary terminals of motor 2, which is fitted with a starter. At the very first moment before motor 1 has started to rotate, an alternating voltage with a frequency of 50 c/s is generated in its rotor, and this voltage is fed into the stator of motor 2, which thus also develops starting torque. The starting current is limited by the starter. As the speed of the motor increases, the secondary frequency decreases, and since the two machines are mechanically connected, they adjust themselves to a common speed, since the secondary frequency in motor 1 is equal to the primary frequency in motor 2. Thus, in this case, the speed of 500 r/m corresponds to 25 c/s.

All operation of the rubber mixer is by means of four pushbuttons; one for each speed, one for stopping, and one for reversing. Reversing can only take place with the motors connected for low speed but, in any case, it has to be used only in exceptional cases. When changing over from the one speed to the other, the secondary rheostat is always connected in, thus limiting the current and making the transition smoother.

Naturally, the space-saving advantages of the geared design remain, even though it should not be necessary to use more than one speed for the rubber mixer which, in point of fact, is quite usual. The division of the load over two motors also makes it possible to run the mixer with only one motor if one of them should be damaged, but, naturally, the load must then be reduced.

The lower part of a small, single-speed mixer is shown in *fig. 8*. The driving gear is, in this case designed, in principle, as in fig. 5, but with the one motor and its gear-wheels removed. The maximum continuous output is 300 h. p. at 25 r/m. Here, the two gear-wheels for connecting the rotors of the mixer together are not combined with the elastic coupling, and, therefore, the space requirements have been somewhat greater. The driving motor, which in

(Continued on page 35)

Evaporator Station in a Sugar Factory

By G. Ramchander

Chief Chemist, Jeypore Sugar Co. Ltd.

TO meet the increased demand for Sugar both in the home market and the foreign market, especially at this juncture for earning the much needed foreign exchange, a number of existing sugar factories have been licensed substantial expansion besides the installation of new units. Most of these expanding units were originally of 400—500 tons cane crushing capacity per day. They are being increased now to 800—1000 tons crushing capacity per day, an 800 Ton Plant being now considered an economic unit.

The bottle necks to higher capacities in a sugar factory are the evaporator, Vacuum Pan and Centrifugal Stations. On their proper working depends the efficiency of operations.

The Evaporator Station is here considered. In its proper balancing, great economies of Steam could be effected. Thereby fuel economy and lower manufacturing costs result. If our Country which has entered the export market just this year is to complete with foreign Countries like Cuba, it is imperative that efforts should be made to reduce the cost of manufacture. Of course already our technical efficiency compares well with those of other Countries. But attempts could be made to improve the same.

In the consideration of the evaporator station the units are calculated for a 1000 Ton a day factory in order to provide amply for future expansions and heavier crushing rates.

It may not be out of place to describe briefly the manufacturing process here as the present article deals with evaporation in a Cane Sugar Factory.

Sugar Cane is crushed repeatedly in a number of milling tandems usually three to four. Each tandem consists of three rollers. Water is added in the penultimate mills for the expanding Cane Cells to absorb it and give up the last traces of Sugar contained in them to the juice. The dilute juice which is about 15 to 16 Bx is quickly warmed to about 50—60°C to prevent bacterial fermentation. The warm juice is limed with mils of lime and Sulphured or carbonated with SO_2 or CO_2 gas so that the end reaction has a pH of 6.9 to 7.0. The Juice is then boiled to about 100 to 102°C. in heaters and then sent to continuous clarifiers where the coagulated muds are separated from clear juice. This clear juice whose Bx. is about 15 to 16 is the starting point for the evaporator's in a sugar factory where it is to be concentrated to a Bx. of 55—60 for being delivered to the Van Pan Station after a secon sulphitation.

In calculating the capacities, it is assumed that the resulting clear juice percent cane is 100. Then quantity of clear juice of 15 Bx resulting from crushing $\frac{1000}{24}$ or say 40 Tons of cane per hour is 40 Tons or 89,600 lbs.

The Bx. of the Syrup being 60, evaporation that should take place is 75%.

Evaporation is to be carried under Vacuum as thereby there is not only steam economy but also absence of caramelization. For if sugar juices are subjected to prolonged heating at higher temperatures, there is a tendency for caramelization.

Multiple effect evaporation under Vacuumatic condition is adopted and the credit for its development is due to Norbert Rillieux, who stated his fundamental investigations as 'Three Principles'.

1. The first principle: In a multiple effect evaporator, for each pound of steam used as many pounds of evaporation with result as there are units in the set.

2. The Second Principle: If Vapours are with-

(Continued from page 34)

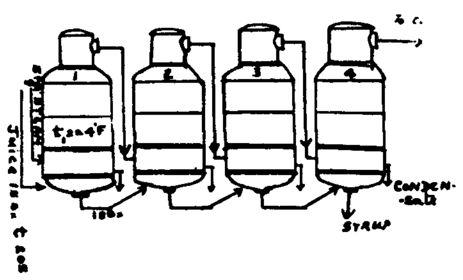
this case, too, is vertical and is fixed to the gear by means of a flange, is almost entirely hidden. This driving set has been used in the main for driving what are known as twin rolling mills. The gear then has double low-speed shaft ends for the direct driving of the two rolling mills and is, in addition, fitted with a built-on, high-speed mechanical brake as an extra safeguard in case of emergency stopping.

drawn from any unit of a multiple effect evaporator to replace steam in a concurrent process, the saving of steam will be equal to the amount of vapour so used divided by the number of units in the set and multiplied by the sequence position of the unit from which vapour has been withdrawn.

3. Third Principle: In any apparatus in which steam or vapour is condensed it is necessary to continuously withdraw the accumulation of non-condensible gas which is unavoidably left in the heating surface compartment.

Formerly in Sugar Factories, evaporation was generally by a Triple effect. Latterly Quadruple effect evaporation with or without a preevaporator or Quintuple effect are being largely adopted. Thereby large steam economics are effected.

In a Standard quadruple effect as shown in the figure, juice and steam are admitted to the 1st body only.



The Juice from the 1st Body goes to the 2nd and then to the third and then to the fourth coming out concentrated from the last body and is called syrup in sugar factory parlance.

The vapour from the vapour space of the 1st body goes to the heating surface or Calandria of the IInd body and is used as the heating medium.

Similarly the Vapour from the IInd body goes to the IIIrd and the vapour from the IIIrd Body is used as the heating medium in the Calandria of the fourth body. The Vapour from the fourth body is flashed to a barometric condenser kept at a minimum height of about 34 feet as per the Vacuum required depending on the altitude of the place.

The condensates from the Calandrias of all the bodies have to be properly removed. Similarly provision is made for the removal of the incondensable gases from the heating surface as per Rillieux's third principle which is a general engineering practice while dealing with heating surfaces.

We thus see that steam is applied only to the first unit of the set.

The heating surface requirements of an evaporator should theoretically be in the form of Heat Transfer Co-efficient. Figures ranging from 200 to 400 BTU for Sq. Ft. H. S. per hour per °F. temperature differences are found in practice. But it is simpler and has become an established practice to express the capacities as lbs. of water evaporated per Sq. Ft. H. S. per hour. These ratings are usually standardized against steam of 5 Psig and 26" Vacuum and a syrup Brix of 65 with a normally clean installation. Some manufacturers give evaporation rates of 10.5 lbs. and 8 lbs. per Sq.Ft. H. S. per hour for Triple and Quadruple installations respectively. Java average figures are 6.4 lbs. and 4.5 lbs. per Sq. Ft. H. S. per hour for Triple and Quadruple installations respectively. In as much as fouling not only inside but also on the outside of the heating surfaces has to be taken in account as the installation is put into use and in as much as cleaning of the external surfaces is not easy and hence is not frequently done, there is a large scope for reduced heat transfer, especially on the heating surface where vapours from juice is used, it is advisable to take lower rates. A figure of 8 lbs. and 5 lbs. per Sq. Ft. H. S. per hour of design purposes may be adopted to advantage. With 40 Tons or 89,600 lbs. of juice per hour and 75% evaporation, total evaporation per hour will be 89,600 × $\frac{75}{100}$ or 67,200 lbs. At 5 lbs. per Sq.Ft. H. S. per hour, this works out $\frac{67,200}{5}$ or 13,440 Sq. Ft. H. S. for the capacity of the Quadruple evaporator station. This should be divided into 4 bodies of equal size i. e. 3360 or say 3500.Sq.Ft. H. S. each.

VAPOUR PIPE SIZING

The size of Vapour Pipe leading from the last body to the condenser is first worked. For if these are undersized, Vapour removal will be imperfect; thereby affecting the vacuum and the working of the station.

Out of the total evaporation at the Station each body is assumed to effect equal evaporation. Then vapour produced in the last body is $\frac{67,200}{4}$ or 16,800 lbs. per hour or 4.66 or 4.7 lbs. per second.

Vol. Occupied by 1 lb. of vapour at 26" vacuum is 175.7 C. Ft.

Then 4.7 lbs. occupy a volume of 825.79 Cft; Velocity of vapour at this vacuum is 200 ft. per second. Therefore, the area of the Vapour outlet pipe should be $\frac{825.79 \times 144}{200}$ or 594.57 Sq. inches. This indicates a Diameter of 28". As this will be an odd size, a Diameter of $2\frac{1}{2}$ ft., is preferable.

The diameter of the inlet flange of the condenser should be the same as the diameter of the vapour pipe.

The condenser should be placed as near the evaporator station as possible so that the vapour travels by a short route avoiding unnecessary and devious bends.

CONDENSER

Next comes the Condenser. Of the many types of condensers, the Barometric one of either the counter current type with baffles and working along with a vacuum pump or the Multijet without the aid of the Vacuum pump are the ones normally used in Sugar Factories. Of late the Multijet is finding extensive use; but this requires a large quantity of cold water.

The height of the condenser is governed by the time required for Vapour to remain in contact with water. If it is a straight condenser without any baffles usually a height of 15 feet is necessary. As all barometric condensers are provided with baffles for a good intermixture of Vapours and water, usually a height 8 to 10 feet is more than ample. Even in the case of Multijet condensers, as the Vapour travels down along with the descending fine jets of water, a height of 10 ft. is ample.

The area of Cross Section of the Condenser is proportional to the quantity of vapours to be condensed. The general practice is to allow 1.5 Sq. Ft. Cross Sectional area per ton of Vapour to be handled per hour.

Then 16,800 lbs. of Vapour produced in the last body requires a Cross Sectional area of $\frac{16{,}800 \times 1.5}{2240}$ or 11.25 Sq. Ft. indicating a diameter of 46" for the Condenser. Instead of this odd size a 4 ft. diameter condenser is preferable.

INJECTION WATER

Injection water is applied to the Condenser to condense all the vapours produced in the last body and flashed to the condenser. Continuous condensation of vapours produced will maintain the Vacuum in the last body; thus enabling the contents of the evaporator to boil at a low temperature. The temperature of the injection water has got an important bearing both on the production of Vacuum and on the quantity of injection water requirement itself. Per lb. of Vapour to be condensed a lesser quantity is required if the temperature is 32°C. than if it is say 37°C. This quantity is called the cooling water Ratio and the general formula for this is

$$W = h - \frac{(t_2 - 32)}{(t_2 - t_1)} \quad \text{where,}$$

W is lbs. of water required per lb. of vapour.

t_1 is the temperature of injection water in °F.

t_2 is the temperature of outlet water in °F.

h is the Total Heat in B. T. U. per lb. of vapour.

The cold water in our country could be got around 90°F. But generally in most of the factories, the injection water after use in the condenser has to be recooled and used again. Hence the temperature usually goes up and an average figure of 95°F. may be safely assumed for the temperature of injection water.

With a good design of the condenser it should be possible to get a difference of about 18°F. between the outlet water and the injection water temperature. Then the outlet water temperature would be 113°F. With these figures, the cooling water Ratio will be

$$1113 - \frac{(113-32)}{(113-95)} \quad \text{or } 57.$$

Thus every lb. of vapour requires 57 lbs. of cold water at 95°F. for the condenser.

Thus to condense 16,800 lbs. of vapour per hour, injection water requirement is $\frac{16{,}800 \times 57}{60 \times 10}$ or 1596 gallon per Minute or say 1600 G. P. M.

If a Multijet condenser is used, about 2000 G. P. M. will give good work.

VACUUM PUMP

Finally comes the Vacuum Pump. The function of

the pump is to create initially a vacuum in the evaporator bodies by evacuating air contained in the bodies, the connected vapour lines to the condenser and the condenser itself.

When once the initial exhaustion is made, the work of the vacuum pump is in the removal of the incondensible gases derived from the vapours and the air contained in the injection water applied to the condenser. The latter quantity differs according to the source from which the injection water is received. According to Perk (1) 0.96 lbs. of incondensible gases will be obtained for every 1,000 lbs. of vapour. Similarly every 1,000 lbs. lake or river water contains 0.024 lbs. of air and every 1,000 lbs. of spray water contains 0.034 lbs. of air.

Thus incondensible gases obtained from 16,800 lbs. of vapour is $\frac{16{,}800}{1{,}000} \times 0.96$ or 16 lbs. per hour or 0.26 of a lb. per minute.

Similarly, air in injection water of a spray as usually obtained in factories is $\frac{16{,}800}{1{,}000} \times 0.034$ or 0.57 lb. Together the air and incondensible gases to be removed is 0.83 of a lb. or say 1 lb. per minute.

This air is to be removed at the top of the condenser at the temperature of the injection water namely 95°F.

At 26" Vacuum, the Total Pressure of the saturated water vapour is 1.96 lbs. per square inch. Vapour pre. corresponding to the injection water temperature of 95°F. is 0.83 per square inch. Therefore, the partial pressure due to air is 1.13 lbs. per square inch.

Then the specific volume of air

$$\text{at NTP is } 0.3697 \times \left(\frac{459.4 \times T}{P}\right)$$

or

$$0.3697 \times \left(\frac{459.4 \times 95}{1.13}\right)$$

or

181.4 C.Ft. per lb.

Therefore 1 lb. of our air and incondensible gases requires a displacement 181.4 C. Ft. for the capacity of the Vacuum Pump.

Tromp (2) calculates the Vacuum Pump capacity as 15% of the volume of injection water. According to him, we have

$$Va = \frac{Vi \times 0.15 \times 14.7}{6.23 \times Pa}; \quad \text{where}$$

Va is the displacement of the Vacuum pump in C. Ft./min.

Vi is the volume of injection water in gallons per minute

Pa is the absolute air pressure at the condenser air outlet in lbs. per square inch.

Then we have,

$$Va = \frac{1600 \times 0.15 \times 14.7}{6.23 \times 1.13} \text{ or 504 C.Ft. per minute,}$$

for the vacuum pump displacement. This will also cover a factor of safety and could be adopted.

Besides it is the practice to use a single vacuum Pump for the evaporator station and the Pan Station. Consideration is to be given separately for the latter.

STEAM SUPPLY

Finally we come to the steam requirement of the evaporator station.

The Heating Steam required per lb. of juice is,

$$Qs = \frac{H}{LS} \quad \text{where,} \qquad \text{—(1)}$$

Qs is the quantity of steam in lbs.
H is the Total Heat required.
LS is the talent heat of steam.

We have seen that steam is applied at 5 Psig to the first body into which juice at 15 Bx. is fed. The Bx. of the outlet juice is around 18. The Factor of evaporation would thus be $1 - \frac{15}{18}$ or $1 - 0.83$ or 0.17.

We have then for the Total Heat requirement as follows:

$$H = Wj\,[(t_1 - t)\,Cj + F \times L] \quad - (2)$$

Where H is Total Heat required in B.T.U. per lb. of Juice.

Wj is the weight of juice at the desired concentration.

t_1 is the Boiling Temp. of juice at the desired Pre. in the 1st body; about 224°F.

t is the juice inlet temperature; usually 205°F.

Cj is the Sp. Heat of Cane juice 0.895

F is the factor of evaporation; 0.17 in our case.

L is the Latent Heat of steam at 5 Psig. i. e. 976

$$\text{i.e. } H = Wj\,[(224 - 205) \times 0.895 + 0.17 \times 976\,]$$
$$19 \times 0.895 + 165.9$$

or

$$182.93$$

i. e. Total Heat required per lb. of juice, taking the concentrated juice at 18 Bx. to be almost equal to the Wt. of juice at 15 Bx., is 182.93. B. T. U.

Substituting this in formula No. (1), we have $Q_S = \frac{182.93}{976}$ lb. of steam per lb. of juice or 0.187 lb. of steam per lb. of juice. Adding 10% extra for radiation losses etc., we may take 0.2 lbs., of steam per lb. of juice.

Then for 40 Tons or 89,600 lbs. of juice per hour, we require 89,600 × 0.2 or 17,920 lbs. of Steam per hour.

The pressure of the steam is assumed at 5 Psig. The velocity should not be more than 150 ft. per second. Higher Steam velocities cause higher vapour velocities, which in turn cause higher resistances and a part of the pressure difference between the bodies will be disturbed. This will reduce evaporation rates.

Condensate should be immediately drained. If condensate removal is improper and there is stagnation, it will also affect a part of the pressure difference between the bodies.

Again removal of noncondensible gases must be properly looked into according to Rillieux's third Principle.

When the above conditions are properly satisfied, efficient working as per the above calculations is assured. Thus we see a total evaporation of 67,200 lbs. for a steam consumption of 17,920 lbs. Thereby giving 3.75 lbs. evaporation per lb. of steam; which satisfies Rillieux's 1st Principle.

If there are deviations in the temperatures of the inlet juice by about 10 or 20°F or if there is too high a concentration in the first body, then there is a larger steam consumption and there will be a deviation from Rillieux's Principle.

Factors affecting evaporator Steam economy will form the subject matter of a separate article. Suffice it to point out here that Rillieux fundamental investigations have largely contributed to economies in fuel saving techniques specially in the Sugar Industry thereby making sugar a cheaper product for the average man.

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INDO-RUSSIAN TRADE

The Indo-Russian agreement which was signed on Dec. 2, 1953, is valid for a period of five years. The Schedule "A" which lists the items available for import into India from Russia, zinc has been added. The chief items of imports from Russia mentioned in the Schedule are: iron and steel manufactures, metals other than iron and steel, mining equipment, heavy electrical plant and equipment, machine tools, ball and roller bearings. Since the signing of the Agreement in 1953, Indo-Russian trade has increased steadily. While the total trade between the two countries stood at Rs. 1.75 crores during 1953-54, the figure for 1956-57 was Rs. 32.41 crores. India had a favourable balance of trade to the extent of Rs. 55 lakhs during 1953-54. During 1956-57, however, the balance of trade was against India to the extent of Rs. 1.41 crores. This was mainly accounted for by large imports of iron and steel products comprising nearly 80 per cent of Russian exports to this country.

MECHANISED FABRICATION OF STRUCTURAL STEEL SECTIONS

Publication Editor — Messrs. Boulton & Paul Ltd., U. K.

This paper describes a system adopted by Boulton & Paul Ltd., for mechanising the cutting and drilling of the component members of steel structures; it discusses the advantages of the new system in comparison with the old. — Editor.

DURING the last 50 years industry has been passing through a change as great as that which took place during the Industrial Revolution when machine power was substituted for hard manual labour. The first machines were, naturally, crude and often combined several functions in order to economise on the limited and very expensive power supplies available. During this century the tendency in industry has been to produce more and more specialised machines, each performing one particular function supremely well. In the motor car and aircraft industries this trend is particularly noticeable and many of the machines found in a modern production line would be of little use elsewhere. A further development has been the attention paid to moving work to and from machines in order to maintain their production as continuously as possible; for this purpose very considerable capital expenditure has been undertaken with the result that the modern processes bear little, if any, resemblance to those of the past.

In the steel trade, too, the differences in the methods of production now and 50 years ago are quite astounding considering the comparatively short period of development, although the old can often still be seen working almost alongside the new. There are still, for example, blast furnaces where the ore is manually handled and charged into the furnaces by large numbers of labourers working at this heavy and soul-destroying job for long hours. The difference between these conditions and the modern blast furnaces where ore is handled almost entirely mechanically, one man doing work for which ten would have been needed 60 years ago, gives a fair picture of the difference between the methods of the 1890's and the 1950's. These changes are almost entirely due to the development of the electrical industry and the substitution of electricity for steam or water power. Many intricate mechanical movements have been made possible by the ease with which electrical switch gear can control the operation of electric motors through a wide variation of speeds and horsepower.

A further change has been experienced in the availability of manpower. During the period under consideration we have moved from conditions where labour was extremely plentiful, and generally under the complete control of the employers, to the present conditions of full employment and acute shortage of the more skilled workmen. As a result of this shortage labour has become very much more difficult to control and in many cases, particularly where tact is not used in management, has even become uncontrollable in comparison with the old standards. In this second half of the century we are moving into an age where, in addition to the factors noted above, the use of electronics is further hastening the changes in industry and we are only dimly beginning to see the possibilities of this new medium, which has already been used for machine control, intricate calculations and the replacement of large staffs of clerical workers.

Studied against this backcloth of change, the methods in the structural industry are, generally, lamentably out of date, the procedure often being almost exactly as it was in the days of our grandfathers. Steel frames for buildings are still laboriously designed from first principles and standardisation is almost unknown in this country although it has been more or less unsuccessfully tried a number of times. Components are still detailed by hand, the detailed drawings passed to the template shop where it is not uncommon to find wooden templates made for every piece and then passed to the workshops to mark holes and notches in various bars. As a result of this failure to improve, numerous other means of construction have received a stimulus to which they should not normally be entitled. The high cost of producing steel framing by conventional methods has allowed the steel industries' competitors in concrete to take one contract after another, while the high cost of producing the conventional riveted structure has given a tremendous incentive to various other means of construction which are often not as suitable for the job.

It was with this situation in mind that Boulton & Paul Ltd., decided to take a first step in the mechanisation of the industry by introducing a mechanical handling plant at their Norwich Works. Their objective was the elimination of template making and marking off as well as a reduction in the handling of steel bars. The system they evolved for this purpose has proved completely satisfactory after a trial period of five years and the amount of labour required for the preparation of sections has been considerably reduced while output has increased and much floor space saved for other work. Contrary to the accepted practice, bars now travel from the stockyard through the cutting and machining processes without the use of a crane except at the start and finish.

The first problem to be solved was the method by which information should be conveyed to the machine operators without the use of drawings or setting up of jigs on the machines. For this purpose a special form was adopted, which is at present made from the detailed drawing on which is stated the Job Number, section and length, cutting particulars, hole diameters and various drillings required. These forms are prepared semi-mechanically, but it is intended that the labour involved in this operation can be materially reduced by the use of further mechanical equipment. Lengths given on the drawings are added in feet, inches and sixteenths so as to provide an automatic check on the calculations. The special form for each bar or batch of bars is first passed to the steel stockyard in the order in which delivery is required and it is the stockyard foreman's responsibility to ensure that the bars are placed on the plant in this order. The bars are then cut on the vertical sawing machine and together with the appropriate form are passed through the plant to the succeeding operations. This method has greatly simplified the work of planning the loading of the shop and has entirely eliminated the stacking of large quantities of cut material at the end on the shop, one of the difficulties encountered with the old system which encouraged this practice so that the platers engaged in marking off should not be idle when the saws were cutting for other jobs. In the old days it was quite usual for two to three hundred tons of cut material to be piled ready for marking off and it frequently happened that the bars which a particular plater required were located underneath a large stack of material. With the new system individual bars are fed through the plant in the order in which they are put on in the stockyard, and as this order can be controlled, no such stock of cut material is required.

Although Boulton & Paul developed this plant primarily for their own use and with no intention of marketing it, in response to many enquiries it was decided to manufacture the plant for sale both at home and abroad. Orders have already been received from Great Britain and Canada and tremendous interest has been aroused throughout the industry. The restyled plants now in production consist essentially of a continuous conveyor, approximately 250' long with storage benches. Sawing and drilling machines are positioned along the length of the conveyor in order to deal with the work in the correct order. The storage benches are necessary to act as a "buffer" on account of the different speeds of operation of the machines working on different jobs. The equipment is designed to handle all structural steel sections, including broad flange beams up to 33" × 15" and, in Canada, stanchion sections up to 18¾" × 16¾" × 426 lbs. per foot in lengths up to 60 ft. A general layout can be seen from Fig. 1.

In the background is the feed bench to the cold saw, which is not visible in the photograph, on which bars

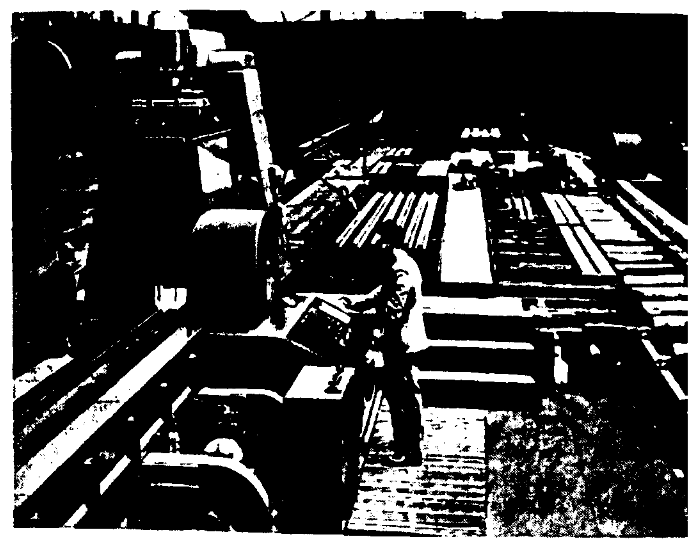


Fig. 1. General Layout of the Equipment

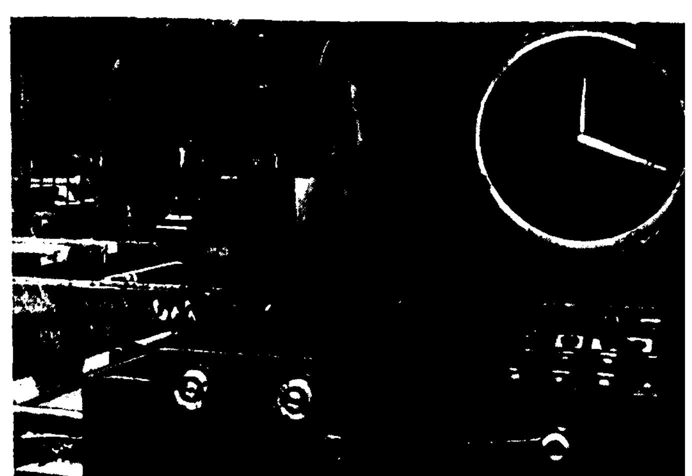


Fig. 2. Vertical Sawing Machine with the control desk

are placed by an overhead crane in the stockyard. The bars are then fed through the saw and after cutting to length, move on to the conveyors leading to the horizontal drill unit, which is seen to the centre of the picture on the right. Bars are processed through this machine and automatically conveyed to the vertical drill seen in the foreground.

When the saw operator presses the appropriate button on his control bench the bar is drawn across the feed bench by dogs fixed to an endless chain and on to a roller conveyor which leads into the saw. A mechanical device centres the bar on this conveyor which, together with the self-centering vices of the saw, ensures that all sections are cut exactly square. The roller conveyor which forms the feed table for the sawing machine is driven through reduction gear by a two speed motor, giving 60' or 10' per minute travel.

The Vertical Sawing Machine, manufactured by Clifton and Baird Ltd., of Johnstone, has a 44" diameter saw blade, and is illustrated in Fig. 2 together with its control desk. This particular Machine was installed in the Works in 1935, but the suitability of its design and condition justified the minor modifications required to incorporate it in the new arrangement.

The Vertical Saw is equipped with self-centering, mechanically operated vices on either side of the saw blade, thus enabling a section to be trimmed at both ends while providing the rigid clamping necessary for the sawing of either single or batches of bars. These vices are driven by a reversing motor through gearing and are controlled by push buttons from the operator's desk. Fig. 3 shows how six angles 6" × 6" × ⅝", eight 6" × 3" channels, or batches of tubes or rounds may be sawn at the same time.

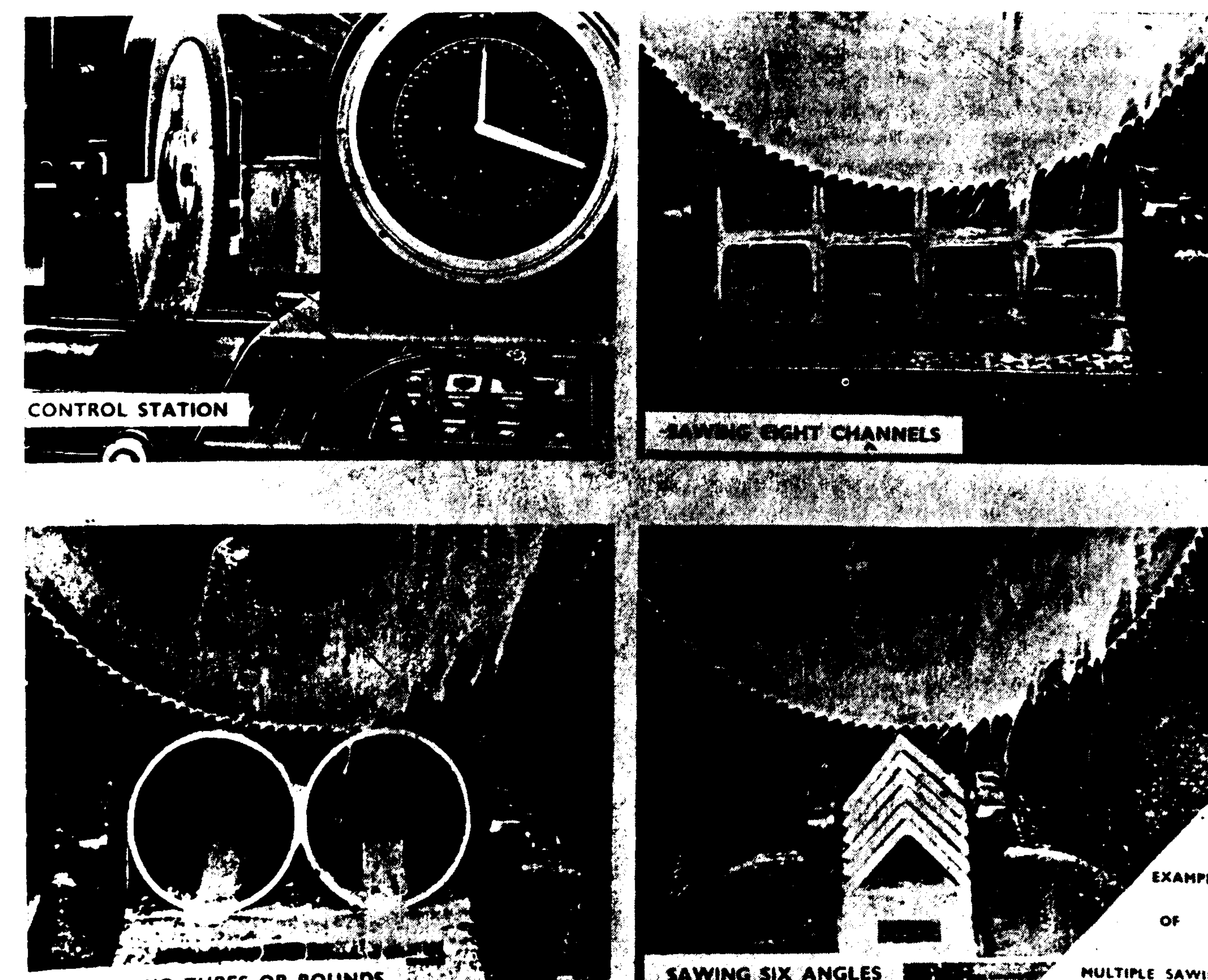


Fig. 3.

The modern design of Vertical Saw now being supplied to British and Canadian orders incorporate the most recent trends in machine tool design, including a hydraulic feed to the saw thus giving infinite variation in saw traverse up to 25 inches per minute together with automatic quick return at the end of the cutting stroke. Suitable saw speeds are also provided for the various classes of materials now in common use.

The method of operation of the machine is as follows. The stock bar is first fed into the saw vices by operating the feed rollers shown in Figure 4. A trimming cut is then taken off the leading end of the bar in order that a surface may be provided from which accurate lengths can be taken. The bar is then traversed through the machine at the rate of 60′ per minute. When the clock type dial indicates that the required measurement is being approached the operator pushes the slow speed button and brings the bar to within an inch of the exact measurement required. He then, by a simple movement, engages his hand wheel control and inches the bar to the exact dimension. When the bar has been carried through the vices it passes on to a second roller conveyor on the other side of the machine and thence to the drilling operators. Movement of the bars between the machines is made automatic as far as can be done with safety. The disposal of bars from the machines is entirely automatic and no attention is required from the operators.

The measuring equipment consists of an endless chain supported on its rollers throughout the length. Being maintained at a constant tension its movement drives the measuring dial spindles through suitable sprockets as the feeler arm travels along with the bar. This feeler arm is kept in close contact with the end of the bar by an ingenious drive mechanism which ensures that a constant pressure is exerted by the bar against this feeler; the distance travelled by the feeler therefore is measured actually by chain pitches rather than absolute distance. In order to ensure that accurate lengths are obtained, means are provided to compensate for chain wear and stretch throughout the length of the chain and by this means, lengths of up to 60′ can be measured with great accuracy. A similar measuring equipment is fitted to the two drilling machines of the plant and each case it is used to determine the position of the various holes required along the length of the bar.

The next unit in the line is a Duplex Multi-Spindle Horizontal Drilling machine manufactured by James Archdale and Co., Ltd., of Worcester. The two heads are each fitted with two banks of three drill spindles each bank being adjustable vertically on the head slides. The centre spindle of each bank is fixed laterally, while the two outer spindles can be moved in this direction from a minimum distance of $2\frac{1}{4}''$ from the centre spindle to a maximum of 6″. The vertical movement is sufficient to drill at the normal cross centres on flanges ranging from $16\frac{3}{4}''$ to 3″ in width. Using the lower bank of drills at its lowest position of $\frac{3}{4}''$ above the feed roller and again at $2\frac{1}{4}''$ above the feed roller it is possible to drill holes at $1\frac{1}{2}''$ centres on a 3″ flange, this double operation is necessary owing to the minimum centres of drill banks being $2\frac{1}{4}''$. However all other flange widths up to $16\frac{3}{4}''$ the holes can be drilled simultaneously at the normal cross centres. With this range of spindle adjustment hole patterns can be drilled from either side from $4\frac{1}{2}''$ wide × $2\frac{1}{4}''$ high to 12″ wide × $14\frac{1}{4}''$ high. By the use of this layout, any holing pattern commonly used in structural steelwork can be drilled without difficulty. The spindles are fitted with No. 3. Morse Taper quick-release sockets providing end adjustment so that drills of a given diameter differing up to 1″ in length can be accommodated. The range of diameters is from 5/16″ to $1\frac{1}{4}''$. As it is not always necessary to drill six holes at a stroke, the drills are arranged so that any spindle can be made inoperative; in this case it simply slides back into its housing and the drill does not penetrate the bar. The gags used for this purpose consist of ' U ' shaped yokes operated by hand levers which slide over the spindles to prevent them retracting. It is therefore possible to drill any number of holes from one in either flange to six holes in each flange without the need to remove any drills. In order that the operators can work from the lists referred to above, it is necessary that the position of each spindle shall be visible to the operator and for this

Fig. 4.

MECHANISED FABRICATION OF STRUCTURAL STEEL SECTIONS

Publication Editor — Messrs. Boulton & Paul Ltd., U. K.

This paper describes a system adopted by Boulton & Paul Ltd., for mechanising the cutting and drilling of the component members of steel structures; it discusses the advantages of the new system in comparison with the old. — Editor.

DURING the last 50 years industry has been passing through a change as great as that which took place during the Industrial Revolution when machine power was substituted for hard manual labour. The first machines were, naturally, crude and often combined several functions in order to economise on the limited and very expensive power supplies available. During this century the tendency in industry has been to produce more and more specialised machines, each performing one particular function supremely well. In the motor car and aircraft industries this trend is particularly noticeable and many of the machines found in a modern production line would be of little use elsewhere. A further development has been the attention paid to moving work to and from machines in order to maintain their production as continuously as possible; for this purpose very considerable capital expenditure has been undertaken with the result that the modern processes bear little, if any, resemblance to those of the past.

In the steel trade, too, the differences in the methods of production now and 50 years ago are quite astounding considering the comparatively short period of development, although the old can often still be seen working almost alongside the new. There are still, for example, blast furnaces where the ore is manually handled and charged into the furnaces by large numbers of labourers working at this heavy and soul-destroying job for long hours. The difference between these conditions and the modern blast furnaces where ore is handled almost entirely mechanically, one man doing work for which ten would have been needed 60 years ago, gives a fair picture of the difference between the methods of the 1890's and the 1950's. These changes are almost entirely due to the development of the electrical industry and the substitution of electricity for steam or water power. Many intricate mechanical movements have been made possible by the ease with which electrical switch gear can control the operation of electric motors through a wide variation of speeds and horsepower.

A further change has been experienced in the availability of manpower. During the period under consideration we have moved from conditions where labour was extremely plentiful, and generally under the complete control of the employers, to the present conditions of full employment and acute shortage of the more skilled workmen. As a result of this shortage labour has become very much more difficult to control and in many cases, particularly where tact is not used in management, has even become uncontrollable in comparison with the old standards. In this second half of the century we are moving into an age where, in addition to the factors noted above, the use of electronics is further hastening the changes in industry and we are only dimly beginning to see the possibilities of this new medium, which has already been used for machine control, intricate calculations and the replacement of large staffs of clerical workers.

Studied against this backcloth of change, the methods in the structural industry are, generally, lamentably out of date, the procedure often being almost exactly as it was in the days of our grandfathers. Steel frames for buildings are still laboriously designed from first principles and standardisation is almost unknown in this country although it has been more or less unsuccessfully tried a number of times. Components are still detailed by hand, the detailed drawings passed to the template shop where it is not uncommon to find wooden templates made for every piece and then passed to the workshops to mark holes and notches in various bars. As a result of this failure to improve, numerous other means of construction have received a stimulus to which they should not normally be entitled. The high cost of producing steel framing by conventional methods has allowed the steel industries' competitors in concrete to take one contract after another, while the high cost of producing the conventional riveted structure has given a tremendous incentive to various other means of construction which are often not as suitable for the job.

It was with this situation in mind that Boulton & Paul Ltd., decided to take a first step in the mechanisation of the industry by introducing a mechanical handling plant at their Norwich Works. Their objective was the elimination of template making and marking off as well as a reduction in the handling of steel bars. The system they evolved for this purpose has proved completely satisfactory after a trial period of five years and the amount of labour required for the preparation of sections has been considerably reduced while output has increased and much floor space saved for other work. Contrary to the accepted practice, bars now travel from the stockyard through the cutting and machining processes without the use of a crane except at the start and finish.

The first problem to be solved was the method by which information should be conveyed to the machine operators without the use of drawings or setting up of jigs on the machines. For this purpose a special form was adopted, which is at present made from the detailed drawing on which is stated the Job Number, section and length, cutting particulars, hole diameters and various drillings required. These forms are prepared semi-mechanically, but it is intended that the labour involved in this operation can be materially reduced by the use of further mechanical equipment. Lengths given on the drawings are added in feet, inches and sixteenths so as to provide an automatic check on the calculations. The special form for each bar or batch of bars is first passed to the steel stockyard in the order in which delivery is required and it is the stockyard foreman's responsibility to ensure that the bars are placed on the plant in this order. The bars are then cut on the vertical sawing machine and together with the appropriate form are passed through the plant to the succeeding operations. This method has greatly simplified the work of planning the loading of the shop and has entirely eliminated the stacking of large quantities of cut material at the end on the shop, one of the difficulties encountered with the old system which encouraged this practice so that the platers engaged in marking off should not be idle when the saws were cutting for other jobs. In the old days it was quite usual for two to three hundred tons of cut material to be piled ready for marking off and it frequently happened that the bars which a particular plater required were located underneath a large stack of material. With the new system individual bars are fed through the plant in the order in which they are put on in the stockyard, and as this order can be controlled, no such stock of cut material is required.

Although Boulton & Paul developed this plant primarily for their own use and with no intention of marketing it, in response to many enquiries it was decided to manufacture the plant for sale both at home and abroad. Orders have already been received from Great Britain and Canada and tremendous interest has been aroused throughout the industry. The restyled plants now in production consist essentially of a continuous conveyor, approximately 250′ long with storage benches. Sawing and drilling machines are positioned along the length of the conveyor in order to deal with the work in the correct order. The storage benches are necessary to act as a "buffer" on account of the different speeds of operation of the machines working on different jobs. The equipment is designed to handle all structural steel sections, including broad flange beams up to $33'' \times 15''$ and, in Canada, stanchion sections up to $18\frac{3}{4}'' \times 16\frac{3}{4}'' \times 426$ lbs. per foot in lengths up to 60 ft. A general layout can be seen from Fig. 1.

In the background is the feed bench to the cold saw, which is not visible in the photograph, on which bars

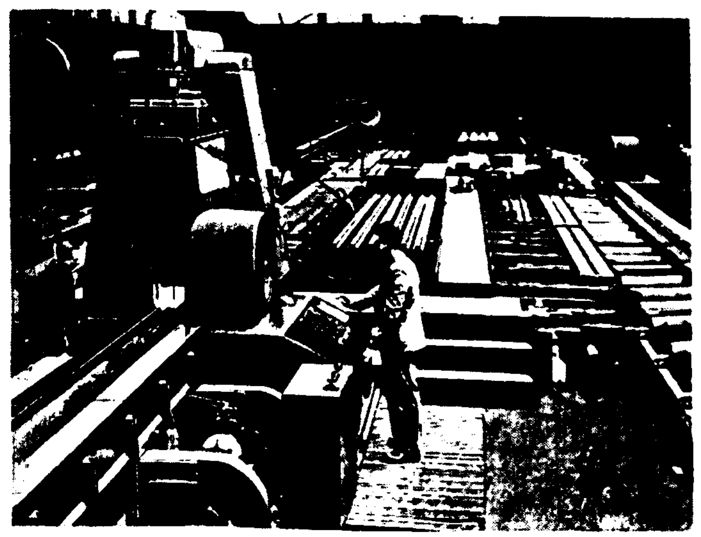


Fig. 1. General Layout of the Equipment

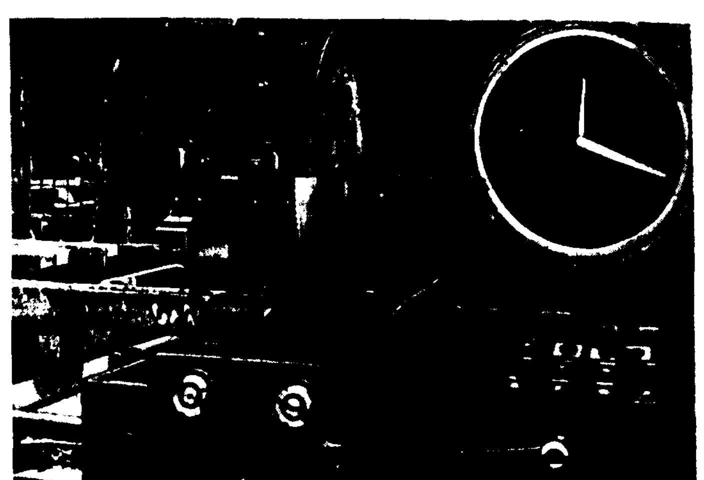


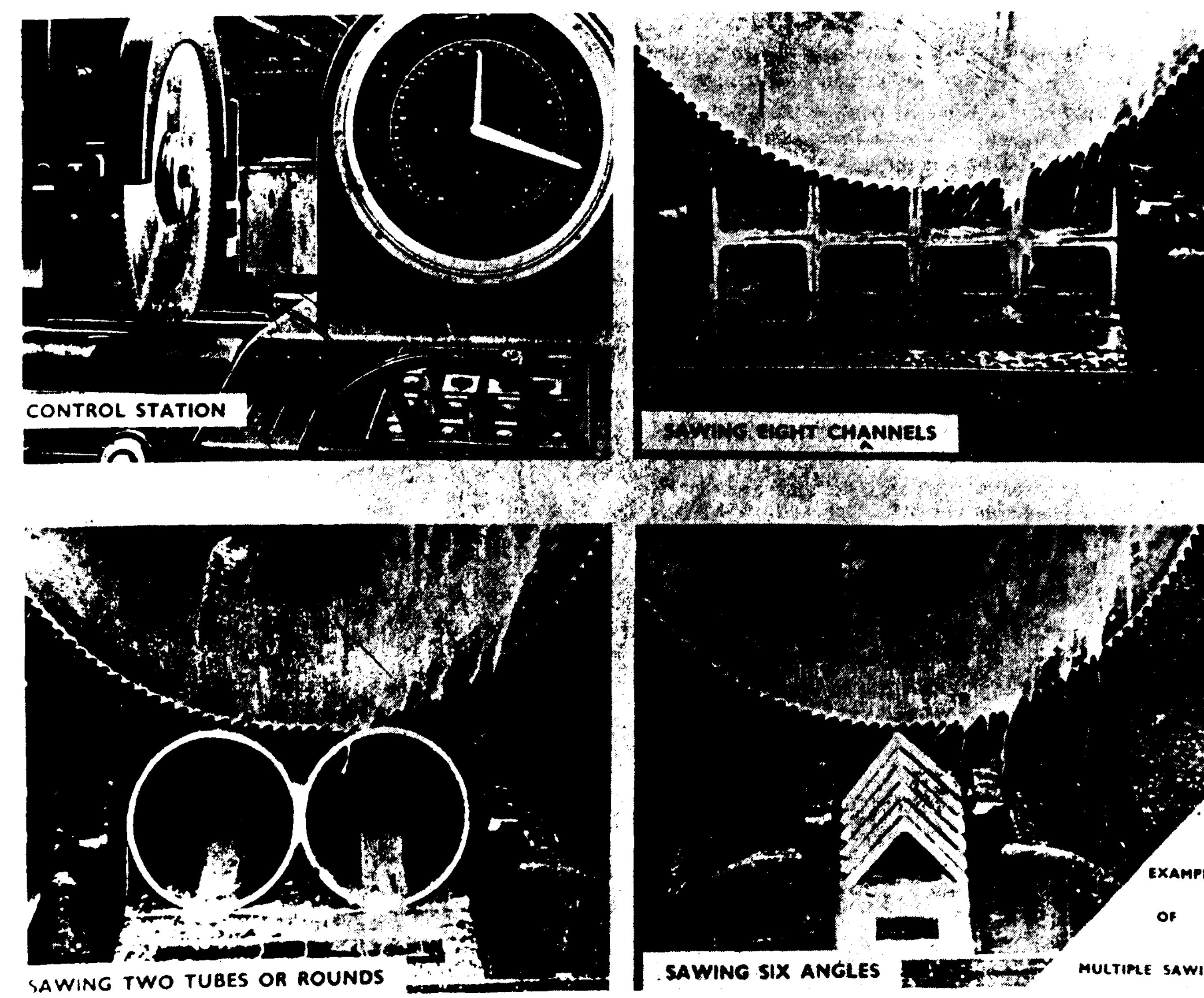
Fig. 2. Vertical Sawing Machine with the control desk

are placed by an overhead crane in the stockyard. The bars are then fed through the saw and after cutting to length, move on to the conveyors leading to the horizontal drill unit, which is seen to the centre of the picture on the right. Bars are processed through this machine and automatically conveyed to the vertical drill seen in the foreground.

When the saw operator presses the appropriate button on his control bench the bar is drawn across the feed bench by dogs fixed to an endless chain and on to a roller conveyor which leads into the saw. A mechanical device centres the bar on this conveyor which, together with the self-centering vices of the saw, ensures that all sections are cut exactly square. The roller conveyor which forms the feed table for the sawing machine is driven through reduction gear by a two speed motor, giving 60′ or 10′ per minute travel.

The Vertical Sawing Machine, manufactured by Clifton and Baird Ltd., of Johnstone, has a 44″ diameter saw blade, and is illustrated in Fig. 2 together with its control desk. This particular Machine was installed in the Works in 1935, but the suitability of its design and condition justified the minor modifications required to incorporate it in the new arrangement.

The Vertical Saw is equipped with self-centering, mechanically operated vices on either side of the saw blade, thus enabling a section to be trimmed at both ends while providing the rigid clamping necessary for the sawing of either single or batches of bars. These vices are driven by a reversing motor through gearing and are controlled by push buttons from the operator's desk. Fig. 3 shows how six angles $6'' \times 6'' \times \frac{5}{8}''$, eight $6'' \times 3''$ channels, or batches of tubes or rounds may be sawn at the same time.



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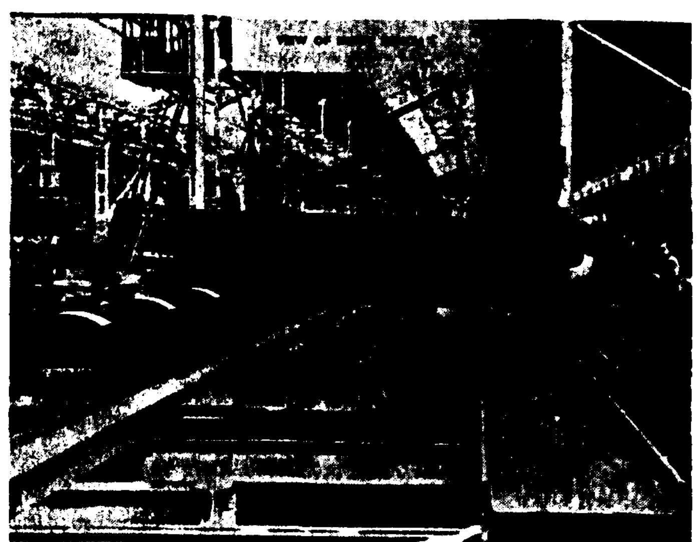


Fig. 4.

TEXTILES SECTION

Recording Spectrophotometer

From A Technical Correspondent, G.E.C., U.S.A.

THE increasing need for accurate color measurement, analysis, and control both in the laboratory and in industry makes the new General Electric recording spectrophotometer a virtually indispensable laboratory and industrial tool.

Completely redesigned to provide greater sensitivity as well as faster and more accurate color measurement, this new recording spectrophotometer is useful in industrial plants for setting up color standards and controlling the color of dyes, glass, inks, and textiles. In laboratories, it is used extensively for chemical, medical, and pharmaceutical analysis.

ADVANTAGES

Increases production by providing fast, accurate control of color processes.

Assures reliable, uniform color standards because instrument provides permanent record of any color in quantitive terms of fundamental physical units.

Furnishes means of rapid colorimetric analysis. Draws complete didymium curve in only 54 seconds.

Draws curve automatically which is accurate within ±0.5 percent.

Plots ordinate automatically for any of following functions:

Percent reflectance or transmission from 0 to 100 percent.

Percent reflectance or transmission from 0 to 20 percent.

Log 1/T (density)

Log log 1/T (log density)

$\text{Log}\,\frac{(1-R)^2}{2R}$

SPECIFICATIONS

Recording spectrophotometer, Cat. No. 7015 E 30 G 1, includes:

1—100% cam
1— 20% cam
1—Set of (2) matched transmission cells
6—Projection lamps
2—Magnesium carbonate blocks
1—Didymium glass filter
1—Amber filter
1—Trouble-shooting manual, GEI-44866
500—Sheets recording paper, NP-159839, 100% ordinant scale

Range

Cat. No. 7015 E 30 G 1—383-700 mmu
Cat. No. 7015 E 30 G 2—380-760 mmu
Special ranges can be supplied.

Approximate dimensions in inches

Length	45
Width	26
Height	20

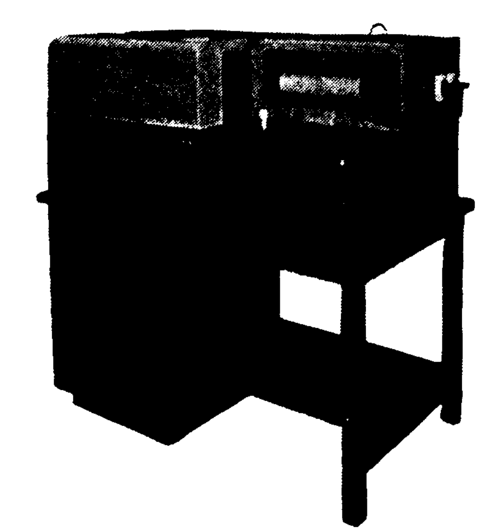


Fig. 1. New recording spectrophotometer plots color curves quickly with fine sensitivity.

Fig. 2. Front view of new recording spectrophotometer.

Approximate weight in pounds

Net	500
Shipping	1350

Power Required: 400 watts at 115 volts (plus or minus 5%), 60 cycles (plus or minus 2 cycles).

Accuracy

Photometric	±0.5%
Wave length	within 1.0 millimicrons

Photometric precision: Within 0.2%.

Band width: 10 millimicrons

Tubes

1—Z1454	2—6AK5
2—6BX7	1—6X4
2—6AG5	1—6AQ5

Recording time

Fast speed	54 seconds
Slow speed	2 1/3 minutes

Publications:

For spectrophotometer Cat. No.	5962004
Renewal Parts Bulletin	GEG-6145
Trouble-shooting Parts and Maintenance Instructions	GEI-22386
Automatic Tristimulus Integrator	GEC-764
For spectrophotometer Cat. No.	7015 E 30 GI
Descriptive Bulletin	GEC-307
Instruction Book	GEI-44866
Automatic Tristimulus Integrator	GEC-764

DESCRIPTION

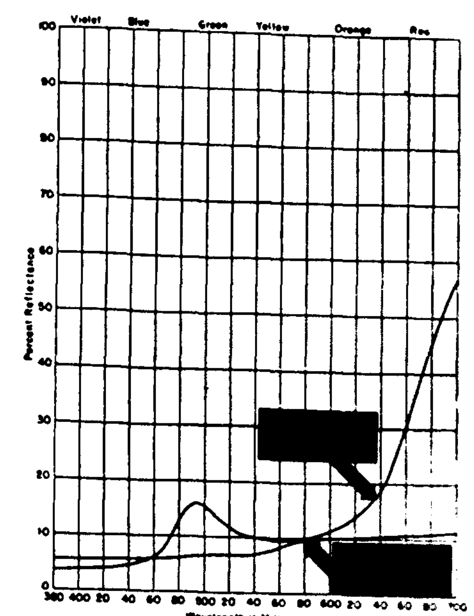
The new recording spectrophotometer consists of three main units—the monochromator, the photometer, and the recorder. All three units are mounted on an iron casting, while the auxiliary chassis, amplifier, and other electrical components are located beneath the casting. The optical system is completely enclosed by a steel cover which has a lift-up section over the monochromator and a removable section over the transmission compartment.

Monochromator

The monochromator system breaks up the white light into the spectrum colors, each at a bandwidth of 10 millimicrons. The light source is a Type C-8 T 10 standard screw-base projection lamp which operates on 6 volts, 18 amperes. The monochromator is a double-prism type and has a range of 380 to 700 millimicrons. This range has been established in anticipation of any possible new colorimetric standards which may be set up by the International Commission on Illumination in the near future.

Photometer

The photometer system illuminates the sample (either by transmission or reflectance) with monochromatic light and furnishes a measurement signal of this light to the recorder. The photometer flicker



system contains three polarizing elements—an analyzing Rochon prism; a Wollaston prism; and a rotating polarizer.

Transmission samples are measured by inserting them in the transmission compartment. This compartment is accessible from the top of the enclosing case. The size of the inspection beam as it passes through the transmission compartment is $\frac{11}{16}$ inch high by $\frac{3}{8}$ inch wide. Flat transmission samples up to $4\frac{3}{4}$ inches by 9 inches can be entirely enclosed in the compartment. Maximum thickness or optical path length is 4 inches. The area to be measured must be within $1\frac{1}{4}$ inches of one edge of the sample. Portions of the closing cover are hinged to permit measurement of large pieces of transparent material by insertion of one corner in the transmission compartment.

A reflection sample is measured by placing it under a spring clamp at the end of the instrument case (Fig. 2). A white standard is mounted under the other spring clamp directly beside the sample. This places the sample and standard against the integrating sphere which is 8 inches in diameter. In operation, the reflection sample is compared to the white standard.

Two port holes in the front of the integrating sphere are provided at a point where the light beams are reflected by the sample and standard. One set of white and one set of black inserts are provided for including or excluding the specular reflection components.

The beam is $\frac{13}{16}$ inch in diameter at the reflectance sample position. Smaller areas can be measured by the addition of special lenses to reduce this beam size. The integrating sphere is positioned so that large panels or doors can be measured simply by pushing the instrument against them.

The phototube, Type Z-1454, is located in the bottom of the integrating sphere. This tube is specially made for its spectral response sensitivity. To assure maximum light, the opal glass plate formerly used over the phototube is replaced by a small lucite cylinder which extends slightly more than half-way into the integrating sphere. Thus, the need for an opal glass diffusing system is eliminated because light reflected from the walls of the integrating sphere is passed directly down to the phototube. This method also results in much higher sensitivity as the light reflected to the phototube is more than doubled.

A completely redesigned electronic system uses only hard tubes, thereby eliminating the need for thyratron tubes. The complete electronic system is mounted on a single chassis which is easily accessible for servicing and maintenance.

The photometer cams control the movement of the recorder pen. Several cams are available which will change the ordinate function as plotted against the wave length. The input will hold five cams which can be changed easily by use of the simple cam shifter lever (Fig. 2). The following cams are available:

1. 0 to 100 percent transmission or reflectance.
2. 0 to 20 percent transmission or reflectance.
3. Log 1/T (density)
4. Log log 1/T (log density)
5. Log $\frac{(1-R)^2}{2R}$

Recorder

The recorder has a specially built drum which accommodates convenient, file-size recording paper (11 by $8\frac{1}{2}$ inches). This paper is easily mounted on the drum. To assure there will be no movement of the recording paper during the running of a particular curve, a bar is provided which holds the edges of the recording paper firmly to the drum.

The recorder pen is driven by a balance motor while the drum is rotated by a wave-length motor. Normal speed for recording is 54 seconds with an optional slow speed of $2\frac{1}{3}$ minutes when used with the automatic tristimulus integrator.

Special recording paper is available for the plotting of all functions versus wave length.

APPLICATION

The recording spectrophotometer provides a curve which is a complete and exact specification unaffected by fading or discoloration. The instrument can be used wherever it is desired to measure color in the visible region or in the near ultraviolet (range 380 to 700 millimicrons).

Color Control

The recording spectrophotometer is useful in any industry where a colored product is manufactured. By comparing a spectrophotometric curve of a

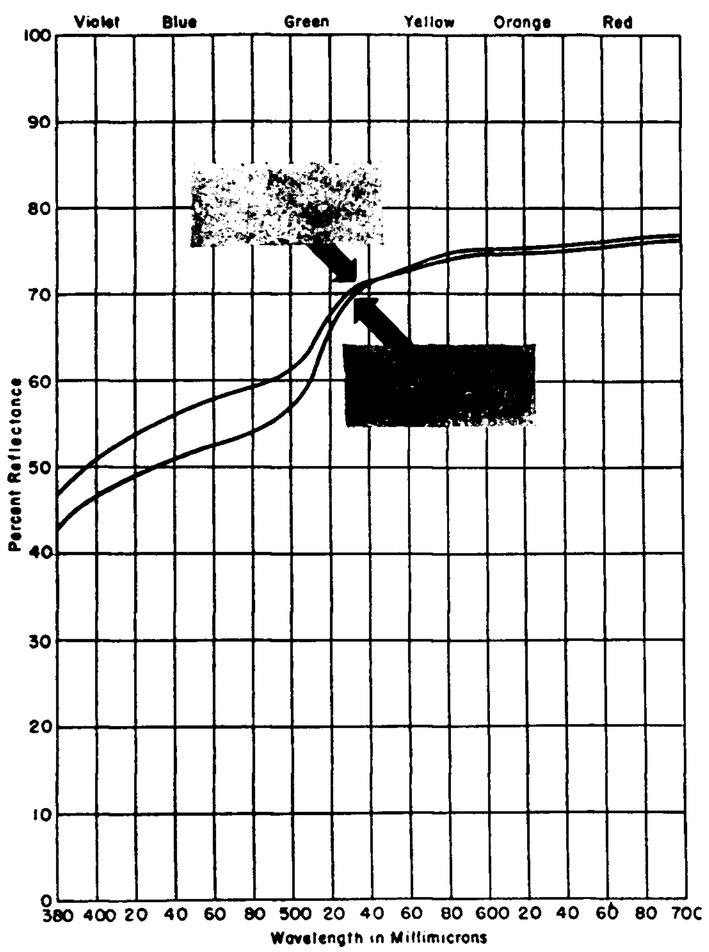


Fig.4. Typical spectrophotometric curves of two samples of yellow printing ink. Actually, the ink is the same, but samples differ in degree of whiteness. Upper curve was produced by use of a thirty-percent engraver's screen; lower curve was made with a thirty-five-percent engraver's screen.

particular pigment against a curve of the desired color, a colorist can determine the exact pigment to add in order to attain a specific color. It is possible to calculate from the curve the amount of a specific component needed as an additive to a "batch" to match a predetermined standard.

Color Standard

In industrial color control, it is virtually impossible to obtain a mixture of pigments in a fixed formula which will produce a series of batches that are all uniform in color. No matter how accurately the proportional quantities are weighed and measured, comparison between batches will indicate a drift from the original color. To minimize this drift, it is customary to match different batches, processes, or productions to daily working standards. These master standards are checked against a carefully preserved standard which is presumed to remain unchanged over a long period.

However, such standards are not reliable indefinitely. Thus, it is more desirable to have some scientific means of measurement or specifications which will positively identify the color of any selected standard. The G-E recording spectrophotometer offers a solution to this problem by providing a permanent record of any color in quantitative terms of fundamental physical units.

The spectrophotometer is proving useful in the textile industry for testing incoming shipments of dyes to determine dye strength. Concentrations of incoming shipments are expressed as a percent of standard concentration and are entered on a control chart. The limits of this chart are set up to indicate the range of acceptable variations in relation to the observed precision of both the dyeing process and the variation of one shipment to another. Far more rapid than previous methods, this test greatly increases accuracy and precision.

Chemical Analysis

The spectrophotometer allows the chemist to make accurate qualitative and quantitative measurements

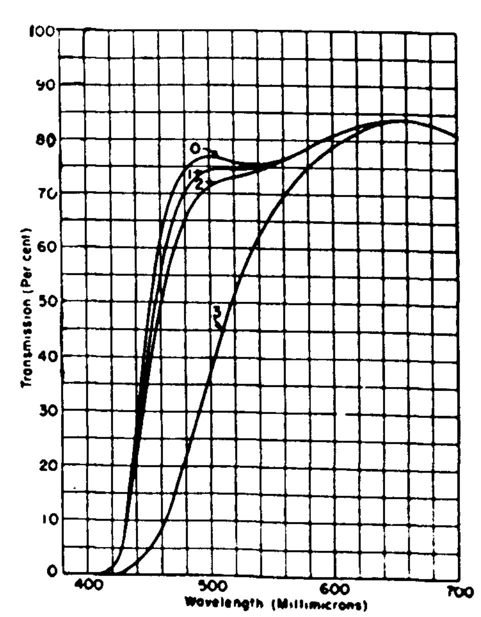


Fig.5. Spectrophotometric determination of titanium in presence of iron. Upper curve shows transmission of a ferric-sulphate solution containing hydrogen peroxide and 100 milligrams of iron in 25 cc. of solution. Other curve shows how transmission changes when different amounts of titanium are added.

and to use his colorimetric methods of analysis with assurance of accuracy.

Because the spectrophotometer records the transmission of the solution for each wave length of the visible spectrum, the chemist can determine color differences which are not visible. The human eye integrates light reflected over the entire visible spectrum, causing colors differing in reflectance at some wave lengths to appear the same (Fig. 3). With the spectrophotometer, precise measurement can be made where accurate visible comparison is difficult or impossible (Fig. 5). At 380 millimicrons, all four curves coincide. Separation begins at 480 millimicrons. In this case, curve "0" shows the transmission of a ferric-sulphate solution containing hydrogen-peroxide and 100 milligrams of iron. It was determined that 0.025 milligrams of titanium had been added to curve 1; 0.050 milligrams of titanium to curve 2, and 0.50 milligrams of titanium to curve 3. These values were found by measuring the transmission at 480 millimicrons and comparing these readings with calibrated curves previously recorded.

The spectrophotometer can detect the presence of very small quantities of materials in solutions which cause color changes. The instrument enables the chemist to quickly measure quantities as small as 1/100 of a millionth of a gram of silver or one millionth of a gram of copper in 25 cc of solution. It can also be used for measuring suspensions of solids in solutions. For example, by measuring the precipitation of silver chloride in water, concentrations as small as 0.2 parts per million of chlorine in water can be measured.

OPERATION

Operation of the recording spectrophotometer is virtually automatic. It consists merely of inserting the sample and standard in their respective holders, placing the recording paper on the drum, and selecting the recording speed. With little instruction, the instrument can be operated by anyone of normal intelligence.

For measuring reflectance samples, a homogeneous sample is placed in the sample holder and a standard white in the standard holder. This combination gives a measure of the sample color relative to the white standard (International color standard is a freshly prepared magnesium oxide—see U. S. Bureau of Standards Bulletin No. LC-547). After the paper is mounted on the recording drum, the operator needs

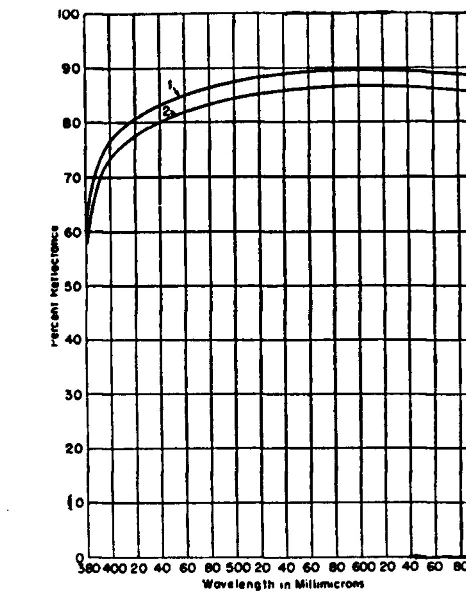


Fig. 6. Both of above curves were drawn on same sample—a titanium white enamel. However, in upper curve (1) the specular component was included while it was excluded in lower curve.

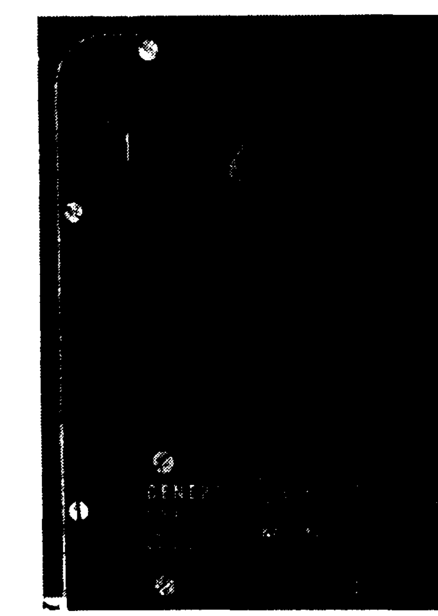


Fig. 7. Control panel located within easy reach of the operation.

only to turn on the wave-length drive and a complete curve is automatically drawn in fifty-four seconds.

Spectrophotometric curves for use as color specifications between various organizations should be recorded with the use of a magnesium-oxide standard. For a color standardization program, it is practical to use a working standard of white vitrolite prepared by the National Bureau of Standards. This can be used as a standard or as a method of calibrating magnesium-oxide standards.

For transmission measurements and color comparison work, magnesium carbonate blocks can be used. Two such blocks are furnished with each instrument. When used, they are placed at both the reflection sample holders at the end of the instrument.

For measuring the effect of gloss, curves can be made which include or exclude the specular component of the light reflected by the sample and standard (specular reflection refers to light reflected in a beam as a mirror). The difference in height between the two curves shown in Fig. 6 can be specified as the measure of gloss of the sample. Provisions are made in the integrating sphere for including or excluding the specular components. Black velvet ports are used when the specular component is to be excluded. Smoked magnesium-oxide ports are used when the specular component is to be included.

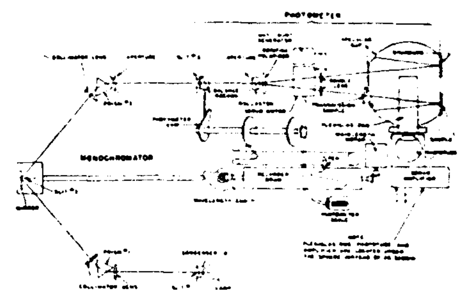


Fig. 8. Schematic diagram showing operation of recording spectrophotometer

G-E Recording Spectrophotometer.

Figure 8 shows the method of measurement on the recording spectrophotometer. The light from the projector lamp is dispersed by prism No. 1. The slit and mirror select a band of light about 10 millimicrons wide. This mirror and slit are driven by the wave-length motor through a cam system so that the spectrum is continuously scanned. A second cam system varies the mechanical width of the slit so that the 10 millimicron band is kept constant throughout the entire spectrum. This band of light is further dispersed by prism No. 2 and trimmed by slit No. 3 to assure spectral purity.

The monochromatic beam is then passed through the polarizing and flickering optical system into the integrating sphere. This beam falls sixty times a second alternately on the sample and standard. If the light intensities reflected by the two are equal, the phototube sees a constant light level. If they are not equal, the phototube sees light variations at a rate of 60 cycles per second. This 60-cycle voltage signal from the phototube is amplified and applied to a servo system which drives a small split-field a-c motor. This motor is connected through the photometer cam to the analyzing Rochon prism.

The servo motor rotates the Rochon prism which changes the light intensity on the standard with respect to the sample by actually varying the intensity of the beams. This action varies the intensity of the beams in relation to each other. This continues until the light intensities reflected by the two beams are equal again. As the phototube no longer sees light variation, the motor stops. The position of the Rochon prism at this point is then the measure of the reflectance of the sample compared to that of the standard. This action drives the recording pen. The position of this pen is the reflectance ratio between the sample and the standard.

Measurement is always made at the point of the zero voltage signal so that it is independent of the characteristics of the phototube, lamp, or amplifier.

Actual operation of the spectrophotometer is simplified by the use of a control panel (Fig. 7). This panel includes a lamp-intensity control which helps assure longer lamp life. It also includes controls for moving the recording pen up or down on the paper for adjustment to a desired position; an adjustable gain control; an ON-OFF switch; and two servo-control switches.

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LENINGRAD PRINTING MACHINES

Improved equipment for print shops is being produced at the polygraphic engineering works.

The new "N-7" linotype has special auxiliaries for automatic temperature regulation of the molten metal, for cooling casts and receiving precise line measuring. The mechanism for the automatic discharge of incomplete lines speeds up setting and increases the linotype's efficiency by 10–15 per cent.

Other improvements have been introduced making it easier to operate the machine.

At present the plant personnel is elaborating new designs of monotypes, an electronic photo type-setting machine and other technique.

Preliminary Report on Service Uses of Cyanoethylated Cotton Products[1]

By Jack Compton
Technical Director, Institute of Textile Technology, Charlottesville, Va.

IN previous publications the mechanism of the reaction of acrylonitrile with cotton and several methods for the production of cyanoethylated cotton products of commercial interest has been described. During the summer of 1956 the Azoton Pilot Plant, designed and installed by the American Cyanamid Company and located at the National Plant of Standard-Coosa-Thatcher Company, Rossville, Ga., was used to produce 2500 lb. of cyanoethylated cotton fiber and yarn, thus bringing the total amount produced in this unit to about 20,000 lb. This cyanoethylated cotton fiber and yarn, together with the 18,000 yd. of cyanoethylated cotton fabrics produced in the semiworks cyanoethylation unit at Monsanto Chemical Company, Texas City, Tex., has been placed largely into a market evaluation program. Reports from about 30% of the cyanoethylated products put into service uses have thus far been made. Some of these have been very encouraging, whereas others have reported that the products did not give the expected performance.

MARKET POTENTIAL OF CYANOETHYLATED COTTON PRODUCTS

In a joint report by American Cyanamid Company, Monsanto Chemical Company, and the Institute, the improved properties of cyanoethylated cotton compared with cotton are enumerated and include: permanently rot—and mildew-proof, more resistant to wet and dry heat degradation, more resistant to degradation by organic and mineral acids, lower moisture regain, altered dyeing characteristics, different stress-strain fiber properties, and altered electrical properties. Using these properties as a basis for a market evaluation program, the proposed end uses in relation to these properties are summarized in Table I. Some idea of the market potential of cyanoethylated cotton products, should its properties prove superior to those of cotton in service uses, may be gained from a study of the report of the National Cotton Council in 1955. Data pertinent to the present problem have been extracted and are shown in Tables II and III. It will be noted that the total potential is over one million bales of cotton annually. Even if only a part of this cotton market was diverted to cyanoethylated cotton, it would be sizeable. It should also be mentioned that that part of the cotton market gained by cyanoethylated cotton is not actually lost to cotton, but rather this becomes a part of the market for cotton. In view of the continuing losses of the cotton market to synthetic fibers, the development of a new fiber material derived from cotton is of importance to a large segment of the population that depend on the consumption of cotton for a livelihood.

TABLE I

Uses of Cyanoethylated Cotton According to Properties Which Should Result in Improved Performance

Mildew—and Rot-Resistant	
Sewing thread	Filter fabric
Seed bed covers	Awning
Tobacco shade cloth	Tents
Tarpaulins	Outdoor furniture
Auto deck and seat covers	Irrigation dams and tubing
Paper makers' felts	Tennis net twine and rope
Sheeting	Tent rope
Fire hose and other hose	Towels
Outdoor wearing apparel	Seed sacks
Shelter halves	Household goods
Shoe lining	Fish lines and nets
Acid Resistant	
Sewing thread	Sacks-fertilizer
Filter cloth	Awning
Fire hose	Tarpaulin
Conveyor belts	Towels
Fender fabric	Paper makers' felts
Wearing apparel (Lab coats, etc.)	Pottery clay
	Filters
Heat Resistant	
Laundry press covers	Tire cord
Enameling duck	Fire hose
V-belts	Abrasive fabrics
Conveyor belts	Laundry padding
Paper makers' felts	Chafer fabric
Industrial dust filters	
Abrasion Resistant	
Abrasives	Shade cloth
Buffer wheel fabric	Sewing thread
Wearing apparel (knitted and woven goods)	Rugs
	Shoe uppers
Sacks and bags	Shoelaces
Paper makers' felts	Bookbinding
Webbing	Hose
Tapes	Towels
Socks	
Electrical Insulation	
Thread	
Fabrics	
Strength	
For all items except insulation and padding	
Dyeing	
Apparel, knit and woven fabrics dye effects	
Sewing thread	
Twine, cord, acid dyes	
Socks	

[1] Azoton registered trade mark for cyanoethylated cotton, Institute of Textile Technology.
This paper was presented at the Fifth Chemical Finishing Conference sponsored by the National Cotton Council of America, October 3–4, 1956, Washington, D.C.

TABLE II

Estimated Cotton Consumption for Various End Uses in Which Cyanoethylated Cotton Performed Satisfactorily

End use		Number of bales
Fish net and lines		30,300
Fish lines	830	
Netting	10,150	
Seine twine	19,320	
Marine ropes		No data
Sand bags (1953 consumption, 500 bales)		10
Filter fabrics		12,000
Seed bed covers		5,180
Tobacco shade cloth		3,780
Rugs		246,700
Abrasive fabrics (buffing wheels)		13,260
Chafer fabrics (machine belts)		67,410
Laundry press covers		67,260
Apron duck	9,790	
Cover cloth	14,140	
Press material	43,330	
Twine (industrial thread)		137,640
Tarpaulins and awnings		121,880
Tarpaulins	62,550	
Awnings	59,330	
Insulating yarn		106,450
Knit goods		Difficult to estimate, but large market
Sutures		No data, but small market
Enameling duck		No data
Hose		39,680
Fire	18,560	
Other	21,120	
		851,550 bales (500 lb. each)

TABLE III

Other Industrial Uses That Could Provide a Market for Cyanoethylated Cotton

End use	Number of bales
Bags (fertilizer)	6,940
Flags	2,720
Friction tape	8,880
Luggage lining	4,240
Mailbags	2,460
Paper makers' felt	8,840
Pick sacks	15,340
Shoes	147,560
Tents	54,670
Wiping cloth	27,460
	278,660 bales (500 lb. each)

SOME MARKET EVALUATION RESULTS

1. *Mildew—and Rot-Resistant*

Cyanoethylated Cotton Fish Lines and Nets. Tests were made by A. von Brandt on 50/15 metric number ply yarn designated as No. 6 thread cyanoethylated at the Institute to nitrogen contents of 3.4, 5.4, and 6.7%. In these tests, the yarns were submerged in the Elbe River Estuary for a total time of 42 weeks. Samples were taken for wet breaking strength tests at various time intervals. The results obtained are summarized in Table IV. It will

TABLE IV

Effect of the Time of Exposure of Cyanoethylated Cotton Fishing Twine in the Elbe River Estuary on the Wet Breaking Strength, in Kilograms

Time, weeks	Avg. temp., °C.	Intensity of attack	% Nitrogen 0	3.4	5.4	6.7
0	6.1	2	7.4	6.5	6.5	6.5
4	10.2	82	0	6.2	6.9	6.3
8	14.0	90		5.7	7.0	6.5
12	18.9	100		—	—	—
16	19.7	100		—	—	—
22	17.8	98		6.4	6.5	6.4
31	12.1	43		—	—	6.4
40	6.9	35		—	7.5	—
42	4.2	—		5.7	7.0	6.5

be noted that the cotton twine had completely deteriorated after 4 weeks, whereas as cyanoethylated twine had lost no strength after 42 weeks, i. e., from April 1, 1955 to January 15, 1956.

Attention is called to the column heading "Intensity of attack," Table IV. This index is the percentage loss in wet tensile strength of an untreated 50/15 cotton twine at the end of 14 days exposure. It will be observed that this index is high when the temperature of the water is high, as might be expected.

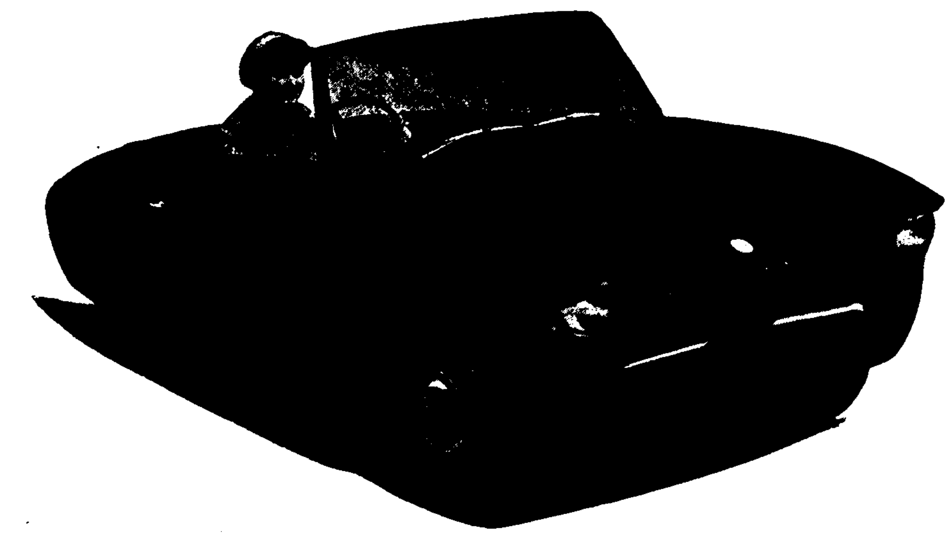
It will also be noted that cyanoethylated cotton twine with a nitrogen content of 3.4% showed about the same immunity to microbiological attack as the twine containing 5.4 and 6.7% nitrogen. There is thus no advantage to be gained in cyanoethylating to the higher nitrogen contents in this particular use.

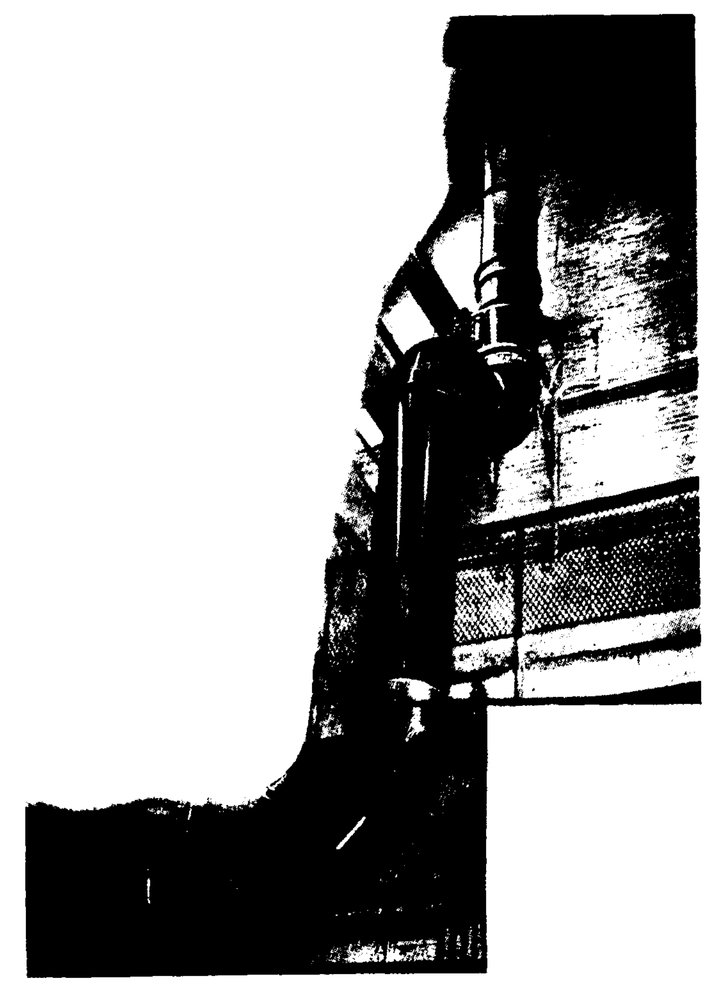
In another series of tests on a cyanoethylated six-thread medium twine, 8.23 finished yarn size with a nitrogen content of 3.4%, it was found that in addition to the twine losing no strength in soil burial tests it only lost about 15% as much wet knot strength as cotton and had essentially equivalent abrasion resistance and only slightly increased elongation.

Finished cotton fish nets may also be cyanoethylated. Nets constructed of 20/9 and 10/18 cyanoethylated cotton twine were evaluated in service. The former twine was used to construct a 1¼ in. mesh net and the latter a 2¼-in. mesh net. The cyanoethylated cotton nets appeared to be somewhat stiffer than similar cotton nets, but this was considered an advantage to the user. The net constructed of 20/9 cyanoethylated twine was considered better than that constructed of 10/18 cyanoethylated twine, but both were very much better than cotton nets of similar constructions in service tests. Some of the twine from the cyanoethylated cotton nets was unknotted and placed in soil burial tests. No evidence was found that the twine deteriorated at the spots where there had been a knot, thus indicating uniformity of cyanoethylation throughout the knots. Knot slippage in the cyanoethylated cotton nets was also found to be higher than for cotton.

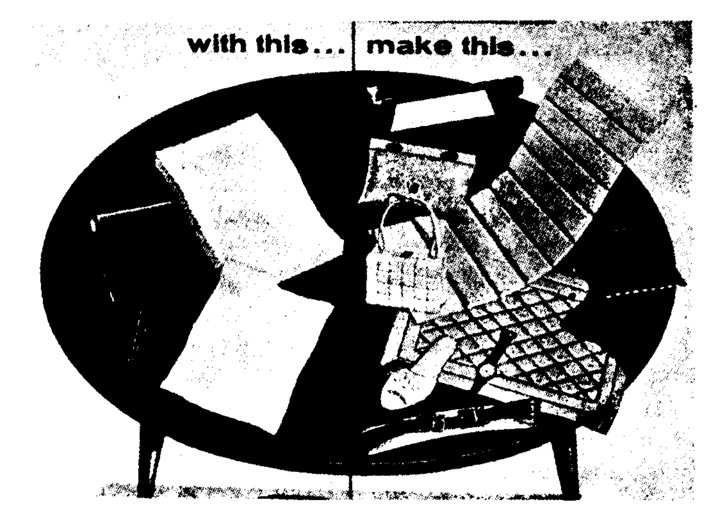
Cyanoethylated Marine Rope. Cotton yarn cyanoethylated to a nitrogen content of 3.8% was plied to make a marine rope ½ in. in diameter. Five strands of this rope, along with similar groups of acetylated cotton, copper naphthenate treated cotton (1.8% Cu), manila, cyanoethylated manila, copper naphthenate (0.15% Cu)-G-4 (0.15%) treated manila and nylon ropes, was mounted in special racks and partially submerged in a fresh water reservoir. Upon testing for breaking strength the results given in Table V were obtained. It will be noted that the cyanoethylated cotton rope had gained 15% in strength, whereas the cotton rope had lost 68%. Acetylated cotton rope lost no strength, and rope treated with the mildewcide copper naphthenate to a copper content of 1.8% had gained 14% in strength. Of some interest also is the performance of cyanoethylated manila rope with relation to untreated manila and manila rope treated with a copper naphthenate-G-4 mixture. This test will be continued until strength losses in the special ropes occur.

—(To be Continued)





PLASTICS & CHEMICALS SECTION



CRYSTOLON "N" — Another Norton Product for High Temperature Requirements

By R. J. Westerholm

CRYSTOLON " N "

CONSIDERABLE interest has been indicated in nitride bonded silicon carbide products over the past few years due to the abnormally high strength exhibited by this material at elevated temperatures. Also due to the fact that silicon carbide bonded by this technique retains its useful properties of high thermal conductivity, good heat, shock resistance, and can be made to relatively close tolerances. Interest in nitride bonded silicon carbide has been stimulated by a great deal of field work that has shown promising results.

Aside from a few select commercial applications, most of the activity has been in the rocket field where combustion liners and nozzles are subject to intense thermal shock, high temperature and gas erosion conditions. A wide variety of nitride bonded SiC nozzles has been supplied to various military establishments and contractors for testing in weapons with which they are primarily working.

One of the most important utilizations is in combustion chambers and throats of rocket motors. This material is offering active competition to so-called fuel cooled rocket motors. The nozzle and combustion chambers are cooled by the flowing of unburnt fuel over the inner surface and the circulation of incoming fuel over the outer surface to extract heat before the metal reaches its softening temperature. Such cooled motors are somewhat intricate and expensive to construct in comparison with the simple motor made possible by an uncooled ceramic lining and nozzle. CRYSTOLON N has been found to be a possible answer for such rocket applications.

In rocket nozzles and combustion chambers, resistance to corrosion and erosion is important, as the gases burn at pressures exceeding 300 pounds to the square inch and flame temperatures, may reach 5000°F. Only the very innermost surface of a ceramic liner and nozzle approaches this temperature, however, since a sharp thermal gradient exists across the ceramic and its supporting cement.

CRYSTOLON N SILICON CARBIDE PRODUCTS

CRYSTOLON N as considered in the present discussion applies to a family of products that includes coarse, medium and fine grain mixtures. These are monolithic products, molded to close final dimensions and kiln-fired at high temperature.

SPECIAL CRYSTOLON N FORMED PRODUCTS

Summary of Typical Properties

Composition	around 80% by weight SiC
Bulk density	2.6 grams per cc.
Permeability	slight
Hardness and abrasion resistance	high
Surface finish	a few hundred micro-inches
Strength	modulus of rupture 10,000 psi at 2300°F.
Modulus of elasticity	20 million psi
Chemical resistance	high
Thermal shock resistance	good
Thermal conductivity	75 BTU/hr. /sq. ft., in./°F. at 1600°F.
Thermal expansivity	28×10^{-7}/°F. linear av. from 70° to 2700°F.
Electrical conductivity	low
Heat resistance	high

Composition: The products are around 80% by weight silicon carbide (SiC).

Bulk Density: About 2.6 grams per cubic centimeter.

Permeability: Although the product is quite dense, some fine pores are present and the product is slowly permeable.

Hardness and Abrasion Resistance: The product is hard and abrasion resistant. It has a clear bell-like ring when struck.

Surface Finish: The product as measured with a Profilometer has a surface roughness of a few hundred microinches.

Strength Properties: The product is very strong compared to other commercial refractory materials. Approximate modulus of rupture at room temperature

- 6,000 psi

at 2300°F. - 10,000 psi.

Mechanical shock resistance is high for a ceramic body.

Modulus of Elasticity: The modulus of elasticity is approximately 20 million psi.

Chemical Properties: Corrosion resistant under many conditions, especially to acids and acid salts. Stable under oxidizing conditions at high temperatures for considerable periods of time.

Heat Resistance: This product is a highly refractory bonded silicon carbide and can be used for considerable periods of time above 2700°F. For short periods of time, use temperatures can be much higher.

Thermal Shock Resistance: The thermal shock resistance, as would be expected for a strong silicon carbide body, is excellent compared to most ceramics.

Thermal Conductivity: At a mean temperature of 1600°F., the thermal conductivity has been determined by the A. S. T. M. method for refractories and found to be 75 BTU/hr./sq. ft., in./°F.

Thermal Expansivity: The average linear coefficient of expansion over the temperature range 70° to 2700 °F. is 28×10^{-7} per °F.

Electrical Conductivity: The electrical conductivity is low and the product may be considered essentially non-conducting.

TEST RESULTS

The test involved an entire rocket motor for one of the large size rockets designed for high altitudes. It represented a missile about 60 ft. in length and a diameter of 5 feet. The throat diameter was about 10 inches. Both ROKIDE " A " Norton's spray coating and CRYSTOLON " N " a monolithic nozzle were tested. Using nitric acid, the flame temperature reached 5000° in a 20 second flame. It was reported as one of the largest successfully tested ceramic nozzle.

CRYSTOLON " N ", RC 4237 tubes were tested under the following conditions :

Time	60	minutes
Max. temperature (outside)	2080	°F.
„ „ (inside)	2120	°F.
Max. temperature difference top to bottom	150	°F.
Fuel/air ratio	.064	
Mass flow fuel air	535	lbs./hr. of propane air

The cylinders did not crack, spall or erode during run or on rapid heating and cooling. The initial heating rate was about 1000°F./min. from approximately 70°F. At the end of five minutes cylinder temperature was about 800°F. in the first minute with cylinder cooling to about 300°F. in five minutes. The excellent condition of the test cylinders after the run indicates they can be used in applications of this type at much higher temperatures.

" Properties of Materials, Uses and Limitations of Different ROKIDE Coatings " — *R. J. Westerholm*

INTRODUCTION

I would like to present to you the most up-to-date information on physical properties that we have available at this time. I feel the best way to do this will be to offer data correlated by our ceramic expert, Dr. Neil N. Ault, of the Research and Development Laboratories in Worcester.

When metal alone cannot be used, three alternatives are available to the high temperature equipment designers. These would include jet engines, rocket engines, gas turbines, etc.

1. Change the design by cooling the metal parts thus increasing cost, complexity, and weight, with sacrifice in efficiency.
2. Substitute non-metallic materials.
3. Protect the metal by coating it.

What are these non-metallic materials which could substitute for metals? No materials can substitute for metals, but some materials can be used at higher temperatures than metals. These are the ceramic materials—oxides, carbides, nitrides, and borides. Unfortunately, these materials do not take over where metals leave off. They must be considered as construction materials only because they are still solid at temperatures above the melting point of most metals. Of all of these non-metallic materials only a small number can be considered for use in combustion atmospheres at temperatures above the melting point of steels.

Even the best of the non-metallic materials are weak compared with metals; they are brittle, and difficult to fabricate. They tend to crack when heated and cooled, nevertheless with proper design, non-metallic materials have been used successfully in rocket engines for some applications.

The third alternative for the engine designer was to protect the metal. Many of the parts of jet engines are now coated with porcelain type enamels, not the same formulation found in bath tubs or washing machines, but still a glassy coating a few mils thick. The coating is produced by spraying a powdered glass on a cleaned metal surface, then melting the glass onto the metal by placing the coated part in a furnace. For this process the melting point of the glass is lower than that of the metal. The function of the enamel coating is to reduce the oxidation and corrosion of the metal, and such coatings may extend the use temperature of a metal by 200 or 300°F.

ROKIDE COATINGS

The ROKIDE coatings, as has been explained, are produced by fusing a solid and projecting the molten particles against a cool surface where they solidify. A very large number of materials can be used for coatings. Almost any material which meets the following requirements can be applied as a coating:

1. Must melt rather than sublime (materials which dissociate may or may not produce a coating.)

2. Must form droplets rather than threads (Glass makes fibers rather than a coating.)

Obviously, there are many many materials which would meet these requirements. The process is not a limited one since it is possible to prepare coatings from elements, compounds, and mixtures of either or both. For example, some of the oxide coatings which have been prepared are: Aluminum oxide, zirconium oxide, titanium oxide, magnesium aluminate, iron oxide, zirconium silicate, and chromium oxide. Porcelains and cermets are examples of mixtures which have been made as coatings.

Out of all the materials which can be used as coatings, alumina, zirconia, and zircon have received the most attention by Norton Company.

ALUMINUM OXIDE COATING

The properties of the aluminum oxide coating, called ROKIDE A, are given in Table I. High purity material is used to keep the melting point and hardness high. It is surprising to note that the alumina has crystallized in cooling as a gamma-type alumina rather than as alpha alumina. Gamma alumina is usually considered to be a low temperature form of alpha alumina. This explains the low true specific gravity of 3.6 grams/cc. Alpha alumina has a true density of 4.0 g/cc. The total porosity, that is, volume of open and closed pores is quite low. Most of this porosity is in the form of open pores. The thermal expansion and thermal conductivity values given in Table I were measured on specimens of the coating. The melting point of the coating is about 3600°F. (2000°C).

Alumina is the hardest of all the oxides; its hardness is employed in grinding wheels. The molten alumina droplets freeze on the surface of the metal and on each other to form an interlocking layer structure of low porosity. The adherence of coating to metal depends on the interlocking achieved by the flattening of the molten particles against the surface being coated. Therefore, a roughened metal surface gives better adherence. This layering effect apparently increases the flexibility of a normally rigid brittle material. A sheet of ROKIDE A can be bent and flexed to a remarkable degree without breaking or cracking.

The general characteristics of this material are that it is chemically stable to its melting point, has excellent corrosion resistance to acids, bases, and combustion gases, either oxidizing or reducing. It is electrically a non-conductor.

ROKIDE ZS

The properties of ROKIDE ZS are given in

Table I. ROKIDE ZS is made from zircon rods. Zircon is the compound zirconium silicate $ZrSiO_4$. This compound dissociates into zirconium oxide and silica in the oxyacetylene flame as the zircon rod melts. The resultant coating consists of fine crystals of cubic zirconia imbedded in a silica-zirconia glass. These phases indicate the rapidity of the quenching and freezing of the molten particles since it is extremely unusual for cubic (or stabilized) zirconia to be associated with a siliceous glass.

Zircon has a somewhat higher density than alumina, but about the same total porosity. While the percentage of closed pores is very low for ROKIDE A (0 to 1%), the closed pores for ROKIDE ZS are about half of the total porosity. This lower porosity and this permeability is a result of the high glass content of the ROKIDE ZS coating. The thermal expansion value given in Table I is for a monolithic body of zircon and, therefore, may not be representative of the coating. This is also true for the thermal conductivity value.

ROKIDE ZS has many of the same characteristics as the ROKIDE A coating. It is hard and adherent, but has a lower permeability, melting point and hardness than ROKIDE A. Corrosion resistance is excellent and it is electrically non-conducting.

ROKIDE Z

The properties of ROKIDE Z are given in Table I. ROKIDE Z is a stabilized zirconia coating, and is produced from a lime-stabilized zirconia rod. The zirconia has a higher density than the ROKIDE A and ROKIDE ZS coatings, but about the same porosity. Porosity values this low are rather remarkable even for sintered monolithic bodies. The thermal expansion for cubic zirconia is somewhat higher than the other ROKIDE coatings. The most interesting properties of the ROKIDE Z are the very low thermal conductivity and the very high melting point. Thus ROKIDE Z will provide excellent thermal insulation.

ROKIDE Z is a somewhat more recent development than ROKIDE A or ROKIDE ZS and thus has not been tested so extensively as the other coatings. Its physical characteristics appear similar to the alumina and zircon coatings. Based on information for zirconia itself, the coating will be resistant to corrosive agents. Electrically, it is a non-conductor at room temperature but its electrical resistivity decreases rapidly above 1200°C.

DISCUSSION

In Table II are listed the properties for three ROKIDE coatings and for stainless steel. Thermal expansions, thermal conductivities and densities are lower for the oxides than for steel, while melting points and hardness values are higher. These properties indicate how such coatings are an improvement over bare steel for resisting the erosion and corrosion of combustion gases. The low thermal conductivities reduce the temperature of the metal backing by insulating it. Densities of the coatings are less than steel and these coatings do not greatly increase weights. Melting points are far higher than steel as well as hardness so that the coatings are not worn away or melted by rapidly moving hot gases.

From the above information alone, it would appear that the coatings are the answers to all high temperature problems, but there are limitations to the coatings also. Ceramic materials are brittle materials. Their compressive strengths are about 10 times greater than their tensile strengths. Therefore, when the coating is stressed it will withstand much more stress in compression without failure than in tension. This is borne out in thermal cycling tests of coatings on concave and convex surfaces. Coatings on concave surfaces such as the inside diameter of a tube will withstand many more cycles of heating and cooling than will a coating on the outside of a tube or cylinder. Stresses are set up by the expansion and contraction of the coating and the metal as the coated part is heated and cooled.

At times another limitation of the coatings is their slight porosity. In some cases with a long enough time corrosive agents will permeate through the coatings and attack the metal. Such attack will be much slower than for uncoated metal.

APPLICATION

Because of their hardness the coatings can be used to reduce erosion of metal parts. The coatings are inert to attack by most chemical agents and stable in combustion atmospheres, so that they will reduce corrosion of metal parts. Their high melting points and low thermal conductivity permits higher operating temperatures or reduces the metal temperature. Relatively thin coatings protecting the metal permits light-weight construction.

TABLE I

PROPERTIES OF ROKIDE COATINGS

	ROKIDE A	ROKIDE Z	ROKIDE ZS
Chemical Composition	98.6% Al_2O_3	98 - % Lime Stab ZrO_2	65% ZrO_2 & 34% SiO_2
Crystal Form	Gamma-type	Cubic ZrO_2	Cubic ZrO_2 Silica Glass
Bulk Density	3.2 g/cc	5.2 g/cc	3.8 g/cc
True	3.6	5.7	4.15
Total Porosity	8 to 12	8 to 12	8 to 12
Thermal Exp.	4.3 × 10-6/°F. 70-2550	6.4 × 10-6	2.3 × 10-6
Thermal Cond.	19	8	15
Total Emissivity	.3-.4	.3-.4	.3-.4
Melting Point	3600°F	4500°F	Glassy phase at about 3000°F
Color	White	Tan	Tan

TABLE II

OXIDES VERSUS STAINLESS STEEL

	ALUMINUM OXIDE	ZIRCON	STABILIZED ZIRCONIUM OXIDE	STAINLESS STEEL
Thermal Expansion (X106/°F) from 70 to 2550°F	4.3	2.3	6.4	12.2
Thermal Conductivity (BTU/hr./ft. 2 in./°F) mean temp. of 1500°F	19	15	8	185
Density (g/cc)	3.2	3.8	5	7.8
Melting Point °F	3600	3000	4500	2600
Hardness, Knoop	2000	1000	750	400

Treatment and Utilisation of Sewage Effluents

By P. V. R. Subrahmanyam, C. A. Sastry and Dr. S. C. Pillai
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DURING recent years there has been an increasing demand for water both for domestic use and for industrial operations, because of the rapid growth of population and of industry. Almost all manufacturing processes require very considerable amounts of clean water. It is also being realised that the natural water resources should be more efficiently used. In this direction important steps have been taken by many basic industries in the United States, particularly in the paper, steel and petroleum refining fields[1]. These industries have found it practicable to re-cycle large volumes of water, thereby reducing their requirements from external sources. While such efforts may be expected to continue, the rapid growth of industry requires constant addition of new water sources to meet the increasing demand. One practical and substantial source for additional industrial water supplies is the effluent from municipal sewage plants[1].

Waste disposal and water conservation are so closely related that it is impossible to separate one from the other. One way of eliminating or reducing water pollution is to make this recovered water available for further use. By so doing, the need for fresh supply of water is reduced, thereby conserving one of the country's material resources.

ATTEMPTS THAT HAVE BEEN MADE TO USE SEWAGE EFFLUENTS FOR INDUSTRIAL PURPOSES

Wolman (1948)[2] discussed the design and performance of a treatment plant for purification of sewage effluent subsequently used in steel mill processing operation at a rate of about 65 million gallons per day at a cost of $ 0.0173 per 1000 gal.

Veatch (1948)[3] discussed the use of sewage plant effluent by various industries, including rail roads and refineries. He listed three conditions necessary for practical reuse of sewage plant effluent by industry, as follows: (1) there must be a local industry which needs water for processes not involving public health, (2) the sewage treatment plant must be large enough to supply the requirements, and (3) the cost of processing, including transporting to the point of use, must be less than the cost of alternate supplies.

Greenberg and Gotaas (1952)[4] discussed the use of sewage plant effluent for replenishment of ground water supplies in California.

Riegel (1952)[5] reported that Kaiser Steel Company at Fontana, California, has for many years been treating and reusing the effluent from their own sewage plant for quenching slag as well as for general industrial purposes, washing, etc.

McCormick and Wetzel (1954)[6] reported that, forced by circumstances of inadequate water supplies from wells, the Cosdon Petroleum Corporation had successfully utilised sewage effluent of the city of Big Springs, Texas, for the previous ten years. After suitable treatment the sewage effluent was used for boiler feed water and also for cooling purposes. More recently arrangements have been made by the industry with the Municipality in Ventura, California, as well as in Texas and New Mexico[7].

Keating and Calise (1955)[1] observed that the major factor involved in the wider application of effluent reclamation is a realisation by industrial managers and plant engineers of the inherent advantages of this use and proper evaluation of the economic and technical factors.

In his lecture on 'Drainage and water supply problems' delivered before the 35th Annual Session of the Institution of Engineers (India) at Bombay in December 1956, Modak[8] also considered the possible use of sewage effluents for industrial and toilet purposes. The effluents could be treated in slow sand filters and then used for boiler feed and cooling water purposes. An outstanding example of the use of effluents after further treatment for industrial purposes is of Bathleham Steel Co., Sparrow Point Ltd. (U. S. A.). "This factory consumes about 185 million gallons of water per day. As this demand could not be satisfied from the domestic water sources of the local authority, the firm entered

PHOTOGRAPHS SHOWING THE USE OF THE EFFLUENT FROM NATURAL PURIFICATION OF FLOWING SEWAGE AT BANGALORE

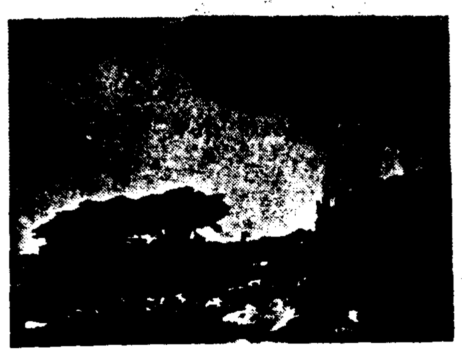

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Figs. 1 to 4: At 1.29 miles (from the sewage outfall) in the natural channel having a gradient of 1 in 50 the purified effluent is being used by dhobis.

Figs. 5 & 6: At 4.75 miles (from the sewage outfall) in the natural channel having a gradient of 1 in 100 the purified effluent is used by the people in the neighbourhood.

In Fig. 5 may be seen women washing clothes. In Fig. 6 may also be seen a woman taking a pot full of the effluent.

into a contract with the Sewage Works Organisation of Baltimore City to purchase from them sewage effluent to the tune of 50 million gallons per day which after filtration and chlorination is used for cooling water and other purposes in the factory. This was found to be more economical than obtaining pure water from other sources. This idea has worked well and the firm is now thinking of purchasing another 50 million gallons of sewage effluent per day, from the nearest Sewage Works. At Grand Canion (U.S.A.) the sewage effluent after sand filtration and chlorination is supplied to the consumers by laying independent pipelines for toilet purposes, i.e. for 'flush' water used in water closets and for cleaning sewers, etc."

CONDITIONS AT BANGALORE

In Bangalore, practically all the sewage is allowed to flow down without any treatment along open channels from three outfalls on the outskirts of the town. The three natural channels taking the sewage have different gradients, viz., 1 in 50, 1 in 100 and 1 in 800. The sewage in the channel having the gradient of 1 in 50, as it covers a distance of 1.29 miles, is purified and is used for washing purposes by dhobis (Figs. 1 to 4). Similarly the sewage in the channel having the gradient of 1 in 100 is purified, but the purification is at a distance of 4.75 miles and here also the purified effluent is used for washing purposes by the people in the neighbourhood* (Figs. 5 and 6).

These effluents have a total hardness of 250 to

300 p. p. m. In view of the above observations it was of interest to develop a simple and cheap method for treating and softening the sewage effluents which are being used for washing purposes. The method would also be useful for the treatment of hard waters.

EXPERIMENTAL

Materials: The following effluents were employed: (1) activated sludge effluent (obtained by aerating sewage with 15 per cent activated sludge over a period of one week by the fill-and-draw method), (2) the effluent at 1.29 miles in the channel having a gradient of 1 in 50, and (3) the effluent at 4.75 miles in the channel having a gradient of 1 in 100. Samples of the naturally purified sewage effluents were periodically collected with the help of the Public Health authorities in Bangalore, to whom the authors' thanks are due.

For comparative purposes, hard water obtained from a local well was also employed. The ion exchange carbon prepared from tea waste was employed in the study[10].

Methods: Calcium, magnesium, iron and aluminium oxides, chlorides and sulphates in the samples were estimated according to the methods given in Theroux *et al*[11].

Experiments: 20 grams of the carbon (20—40 mesh material) was weighed into a glass tube of 1 inch diameter in which it was supported on a layer of glass wool spread over a one-holed rubber cork. 5 per cent sodium chloride was then passed through it till the effluent showed no acidity to methyl red, thus indicating that all replaceable hydrogen ions of the carbon were exchanged for sodium. The bed was then washed free of excess sodium chloride (as tested by silver nitrate). Then 500 ml. of 1 per cent calcium chloride solution was passed through the bed. The bed was washed free of calcium chloride and then again regenerated, using sodium chloride as described above. At this stage, the various sewage effluents and the hard water were passed through the bed and the volume of each effluent and the water that could be treated for rendering them as soft as the tap water in Bangalore was estimated. The results obtained are given in tables 3 and 4. The quality of the effluents is given in table 1. The result of the chemical analysis of the effluents, the sample of hard water and the tap water are given in table 2.

TABLE 1

Quality of the sewage effluents employed

(Results of chemical analysis expressed as p.p.m.)

	Effluent from the activated sludge process.	Effluent from the sewage channel having a gradient of 1 in 50 (at 1.29 miles from the outfall).	Effluent from the sewage channel having a gradient of 1 in 100 (at 4.75 miles from the outfall).
Turbidity*	17	19	21
Oxygen absorption:			
3 minutes	1.6	2.2	1.8
4 hours	8.2	10.0	11.2
Dissolved oxygen	8.4	7.4	7.8
Biochemical oxygen demand (B.O.D.)	11.2	14.3	10.0
Nitrite nitrogen (N)	0.4	2.0	0.8
Nitrate nitrogen (N)	30.0	1.0	0.6
Total bacterial count (in millions)	0.001	0.002	0.002

* Values obtained by using Klett Summersion colorimeter with 420 filter.

TABLE 2

Mineral composition of the sewage effluents and the hard water from a well

(Results expressed as p.p.m.)

	Effluent from the activated sludge process.	Effluent from the sewage channel having a gradient of 1 in 50 (at 1.29 miles from the outfall).	Effluent from the sewage channel having a gradient of 1 in 100 (at 4.75 miles from the outfall).	Well water.	Tap water (Bangalore water supply).
Calcium (Ca)	29.50	62.20	65.30	115.20	15.50
Magnesium (Mg)	11.00	24.02	27.60	19.30	4.50
Chloride (Cl)	61.00	150.00	224.00	230.00	15.00
Sulphate (SO_4)	21.42	18.40	46.70	71.10	4.65
Calcium hardness*	73.63	155.25	162.97	287.53	38.68
Magnesium hardness*	45.25	98.82	113.55	79.40	18.51
Total hardness*	118.88	254.07	276.52	366.93	57.19

* Hardness expressed as calcium carbonate ($CaCO_3$).

In all cases excepting the effluents from natural purification, there were only negligible amounts of iron and aluminium oxides.

TABLE 3

Extent of softening of the sewage effluents and the well water by treatment with tea waste carbon

(Results of chemical analysis expressed as p. p. m.)

	Effluent from the activated sludge process.	Effluent from the sewage channel having a gradient of 1 in 50 (at 1.29 miles from the outfall)	Effluent from the sewage channel having a gradient of 1 in 100 (at 4.75 miles from the outfall)	Well water
Volume treated (in litres)	18.50	6.50	6.50	3.50
nfluent :				
alcium (Ca)	29.50	62.20	65.30	115.20
lagnesium (Mg)	11.00	24.02	27.60	19.30
otal hardness (as $CaCO_3$)	118.88	254.07	276.52	366.93
ffluent :				
alcium (Ca)	10.47	8.32	9.78	8.67
lagnesium (Mg)	7.45	9.72	10.26	8.83
otal hardness (as $CaCO_3$)	56.79	60.78	66.63	57.96

TABLE 4

Total removal of calcium and magnesium from the sewage effluents and the well water by 20 gm. of tea waste carbon.

	Volume treated (in litres)	Removal of Calcium (in mg.)	Removal of Magnesium (in mg.)	Removal of Total calcium plus magnesium (in mg.)
Effluent from the activated sludge process	18.5	352 05	65.67	417.72
Effluent from the sewage channel having a gradient of 1 in 50 (at 1.29 miles from the outfall)	6.5	350.22	92.95	443.17
Effluent from the sewage channel having a gradient of 1 in 100 (at 4.75 miles from the outfall)	6.5	360.88	112.71	473.59
Well water	3.5	372.85	36.65	409.50

DISCUSSION AND SUMMARY

The results given in tables 2 to 4 indicate that the carbon prepared from tea waste is useful in softening sewage effluents as also hard waters. The treated samples of the sewage effluents and well water were as soft as tap water available in Bangalore. It is essential to chlorinate the treated sewage effluents before they are used.

It was also observed that 20 gms. of the carbon could treat about 18.5 litres of the effluent from the activated sludge process and about 6.5 litres of the effluents from the natural purification of flowing sewage. The corresponding volume of hard water from a local well that could be similarly treated was about 3.5 litres. In other words, one pound of the carbon from the tea waste could treat per cycle (for bringing down the hardness to that of tap water) 93 gallons of the activated sludge effluent, 33 gallons of the effluent from the natural channels of sewage purification and 18 gallons of the well water. After the regeneration of carbon with sodium chloride (as indicated in the earlier paper[10]), the carbon could be further used for the treatment of the effluents and water.

It is interesting to note that waste materials such as tea waste and properly purified sewage effluents, after suitable treatment, could be utilised particularly for meeting the increasing demand of water for industrial purposes. The economics of the process involved have to be worked out. But the possibilities in this direction seem to be considerable.

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REOPLEX POLYESTER PLASTICISERS

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POLYVINYL CHLORIDE AND PLASTICISER TECHNOLOGY

THE advent of polyvinyl chloride in the late 1930s provided industry with a polymer with latent rubberlike properties, capable of being developed to varying degrees by the introduction of plasticisers. It soon became apparent that the introduction of this polymer found our knowledge of plasticiser technology inadequate. During the war years 1938—45, when it became essential to conserve natural rubber, extensive studies were made on the plasticisation of PVC and synthetic rubbers. The laboratories of The Geigy Company Ltd., Plastics Chemicals Division, were able to play their part in these studies under the auspices of the Ministry of Supply. The collected reports on this work were subsequently published by H. M. Stationery Office (1).

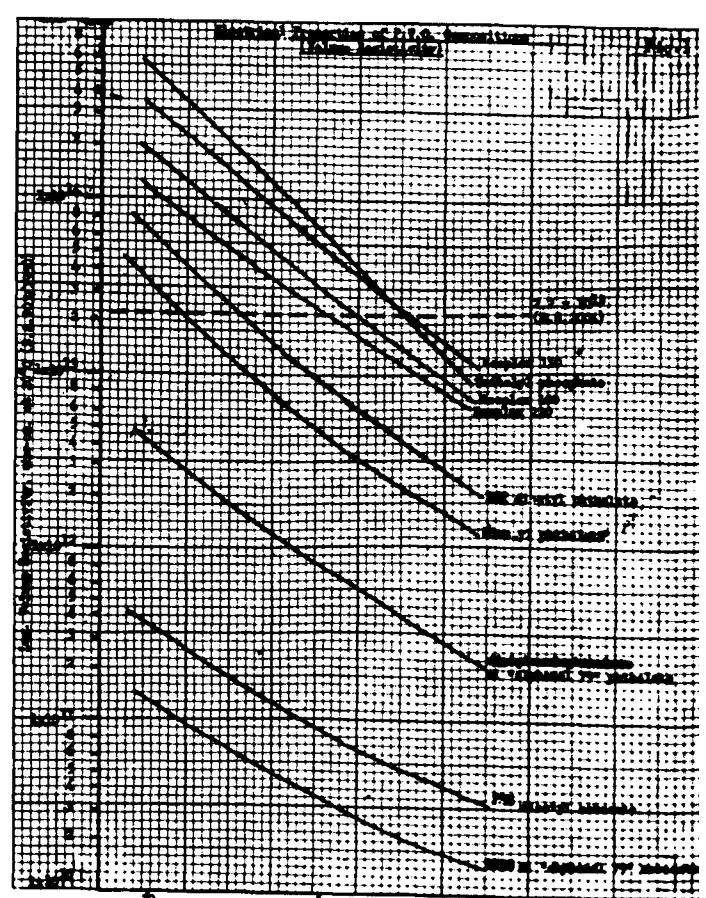
Previously we had been concerned mainly with the plasticisation of the cellulosic types, cellulose nitrate and cellulose acetate. These polymers had no inherent low temperature properties capable of development by plasticisation, neither did they accentuate a desire for plasticisers of lower volatility. Cellulosic plasticisers such as tritolyl phosphate (formerly known as tricresyl phosphate) and dibutyl phthalate, with which the PVC era began, were now found lacking in at least one of these two properties when used in the new polymer. Tritolyl phosphate, though it had excellent fire retardant properties, very low volatility, very good resistance to extraction by aqueous liquids, oils and fats, and low migration into solid hydrocarbons, e. g. rubber, was soon found to be poor in low temperature performance and migration into cellulose nitrate. Dibutyl phthalate proved capable (by use in admixture) of correcting in some measure the poor low temperature properties of tritolyl phosphate, but only so long as it remained in the PVC compound. It was, however, too volatile for such systems.

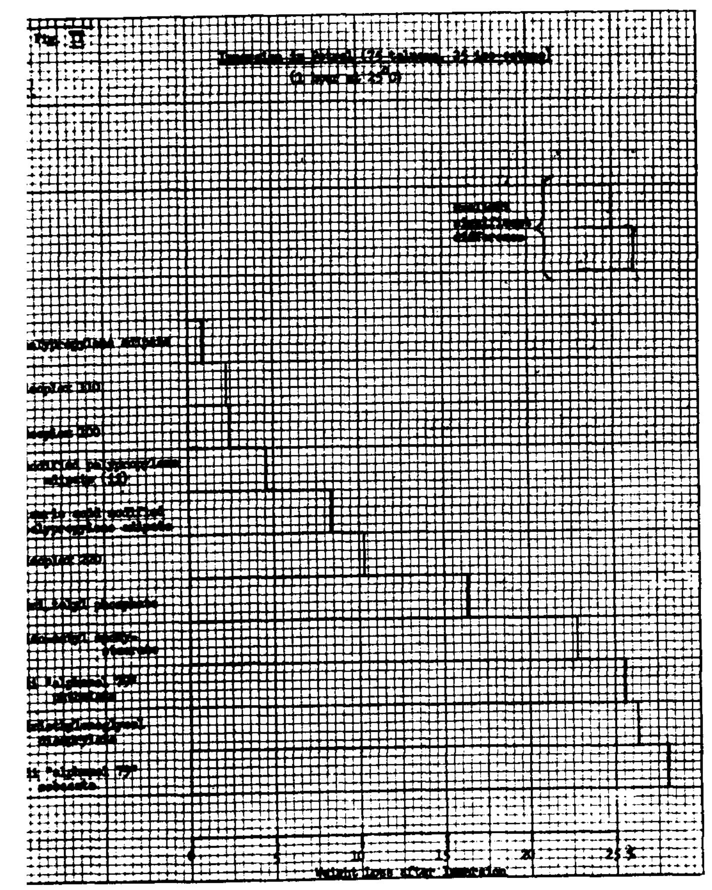
The first advance on this situation was the introduction of the higher alkyl phthalates, such as dioctyl phthalate, now supplemented by the phthalate diesters of capryl alcohol, isooctanol, nonanol, isodecanol and alphanol 79. With the accent on further improvements in resilience and low temperature performance the higher alkyl esters of sebacic acid, azelaic and adipic acids were introduced.

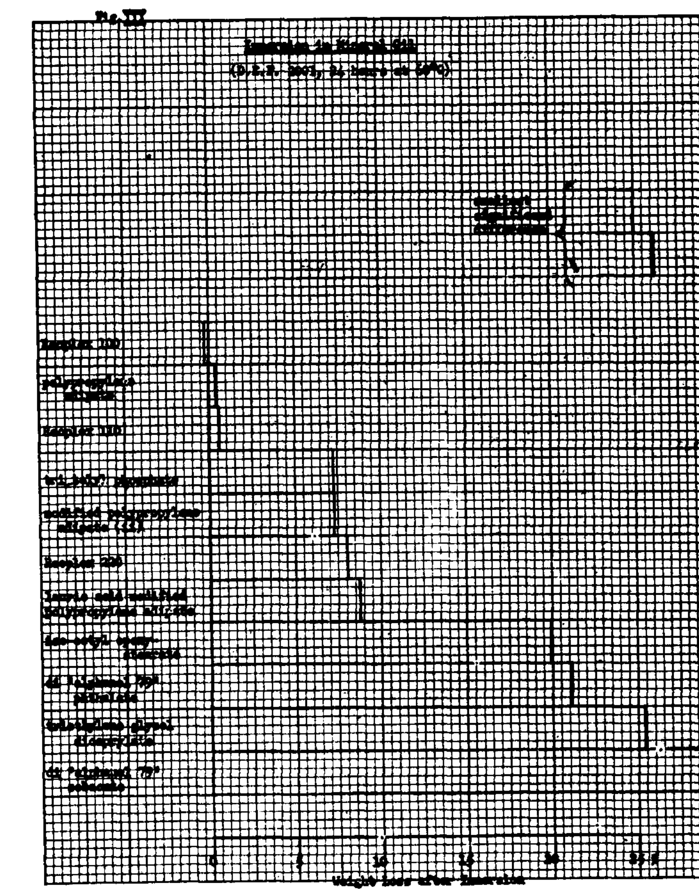
To-day we draw the bulk of our simple di—and triester plasticisers from these three groups, that is, the triaryl phosphates, the higher dialkyl phthalates and the sebacates, etc., and in addition one or two special types such as the fatty acid diesters of polyethylene glycols. From these we can obtain a suitable balance of properties for many applications.

INTRODUCTION OF POLYESTER PLASTICISERS

Industry is, however, insatiable in its demand for improved performance from the materials







it consumes, and plasticisers are no exception to this. The first demand, which could not be met by the simple esters, was in connection with the transmission of radio frequency signals through cables for radar. The ideal dielectric material was already available in polyethylene. It was thought desirable to cover the polyethylene insulated cable with a protective sheath of plasticised PVC. Unfortunately the excellent dielectric properties of polyethylene are impaired by the absorption of small quantities of plasticiser from the PVC sheath, in other words by the migration of plasticiser, and simple ester plasticisers proved too migratory for this application. The use of a polyester plasticiser, polypropylene sebacate, in the PVC sheathing, was the answer to this problem.

Polyester plasticisers have low migration, or none at all; they are resistant to leaching by aqueous and non-aqueous media and are non-volatile. Hence they have excellent ageing properties. There are now many specialised uses for this class of plasticiser, a number of which are discussed below.

CHEMICAL STRUCTURE AND ITS EFFECT ON PHYSICAL PROPERTIES

Polyester plasticisers are produced by the esterification of dicarboxylic acids or anhydrides of the same with polyhydric alcohols, usually glycols. In the main, these plasticisers are made from aliphatic dicarboxylic acids, such as sebacic and adipic acids, though some are based wholly or partly on phthalic acid (anhydride of o-phthalic acid). The glycol used is usually 1, 2-propylene glycol, but others are possible; and to some extent trihydric alcohols can be used, such as glycerol.

The use of an aliphatic dicarboxylic acid and a glycol gives two possible types of product: (a) a polyester from these two components; (b) a polyester as above with end group modification, either esterifying hydroxyl end groups with a monocarboxylic acid or esterifying carboxylic acid end groups with a monohydric alcohol. These two types of unmodified and modified polyesters may be represented ideally as follows:

(a) $HOOC-R'-COOH + HO-R''-OH \longrightarrow HOOC-(R'-COO-R''-OOC-)_n R'-COO-R''-OH$

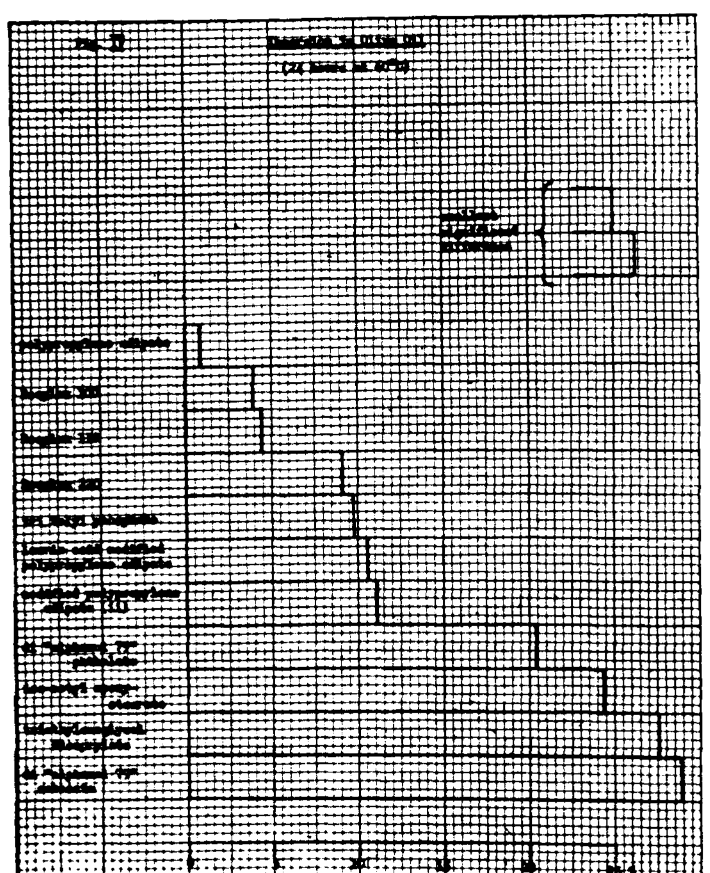
(b) By introducing into the above reaction either $R'''-COOH$ or $R^{iv}-OH$

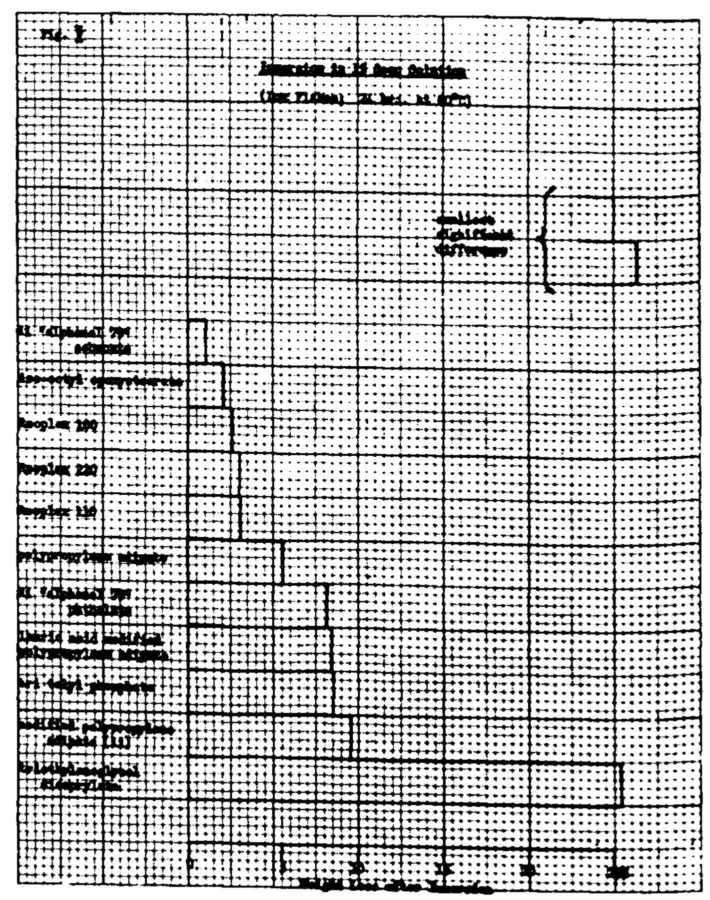
$$\longrightarrow \text{HOOC} - (\text{R}' - \text{COO} - \text{R}''' - \text{OOC} -)_n$$
$$\text{R}' - \text{COO} - \text{R}'' - \text{OOCR}'''$$
$$\text{or}$$
$$\text{R}^{\text{IV}}\ \text{OOC} - (\text{R}' - \text{COO} - \text{R}'' - \text{OOC} -)_n$$
$$\text{R}' - \text{COO} - \text{R}'' - \text{OH}$$

The ideal however is not achieved in practice, though it can be said that in general the unmodified (a) types are usually produced with high viscosities and high molecular weights (e. g., 100 to 2000 poises at 25° C, and molecular weights of 3000 to 8000), while the modified (b) types have considerably lower viscosity and molecular weight (e. g. 5 to 20 poises at 25° C and 1000 to 2000 molecular weight). All types can also be characterised by a degree of free carboxyl and hydroxyl content.

Because of their polymeric or long chain structure the vapour pressure of these types is extremely low, and consequently they have low volatility and good ageing properties when incorporated with PVC, synthetic rubbers and other polymers with which they are compatible. For the same reason they do not diffuse readily out of polymers with which they are compounded, or into other polymers and solid substances with which such compounds are in contact; in other words they have low migration or none at all. In contrast the simple ester plasticisers, because of their relatively small molecular size, diffuse readily through polymer systems once a concentration gradient has been established. For example, while a PVC/TTP composition is fairly stable when in contact with natural rubber compounds, because TTP is not attracted to rubber, most other simple ester plasticisers will migrate under such conditions; and both TTP and most other simple ester plasticisers will migrate readily into cellulose nitrate. PVC systems, polyethylene and leather. In short, a polyester plasticiser will resist migration from a PVC composition even if it is in contact with another medium with which it is compatible. The situation has been likened to the difference between shaking sand (simple ester plasticiser) out of a bundle of loose textile fibres (PVC polymer) and shaking threads of a coloured textile fibre (polyester plasticiser) out of a bundle of loose uncoloured textile fibres (PVC polymer).

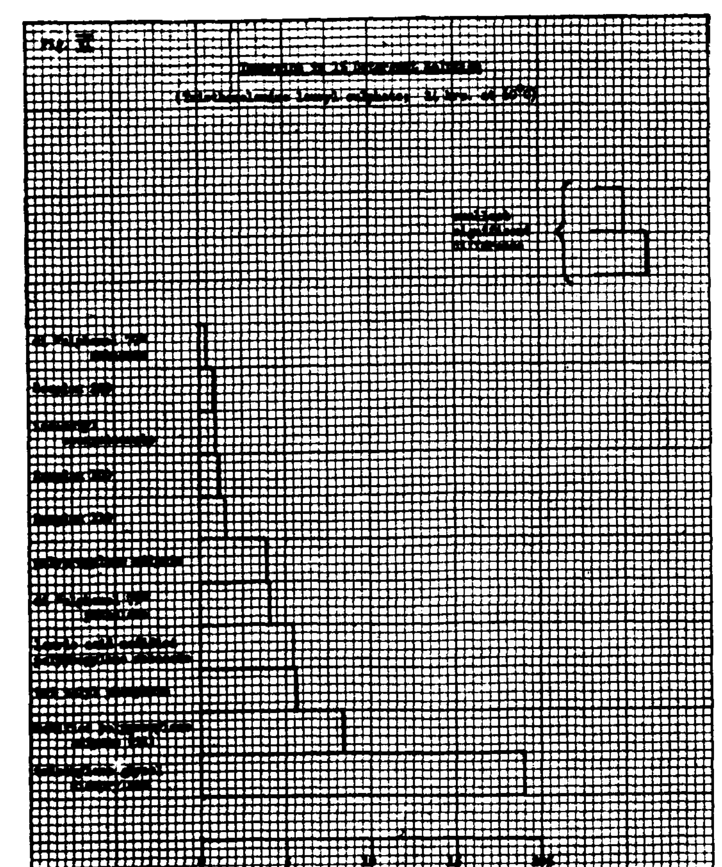
Similarly with resistance to extraction by liquids,





difficulty in diffusion precludes easy extraction. From PVC, for example, extraction is obviously most marked when caused by solvents which have a swelling action on the PVC and open up its polymer structure, thus allowing easier diffusion of the polymeric plasticiser. Such diffusion is, however, usually of a lower order than with the simple di-and triester plasticisers. Extraction by aqueous media, especially at high temperatures, is not so easy to predict.

In respect of volatile losses, migration and resistance to extraction, the high viscosity unmodified polyesters are superior to the lower viscosity modified types. The reason why both types are manufactured is to effect a compromise with regard to other properties. The unmodified types are more difficult to process in that, being less powerful solvents of PVC, they must be processed at temperatures higher than normal. At such high temperatures special care must be taken in adding lubricants to prevent sticking to the roll-mill and calender. At the same time the low temperature properties of the unmodified types are poor, being of the same order as with TTP; but electrical properties, as with TTP, are excellent. With the modified types processing is easier and low temperature properties are improved. Mixtures of the two types can, of course, be used, and mixtures of either or both types with simple ester plasticisers are effective for many applications.



REOPLEX TYPES

REOPLEX 100: An unmodified polyester based on sebacic acid for use in PVC and synthetic rubbers.

REOPLEX 110: Essentially an unmodified type based on sebacic acid for use in PVC and synthetic rubber.

REOPLEX 220: A modified type based on sebacic acid for use in PVC with easy processing characteristics.

REOPLEX 300: A modified type based on sebacic acid, essentially for use in cellulose nitrate finishes giving low migration, e. g., into leather, low extraction by polishes, and low volatility. Also for use in synthetic rubber for good low temperature properties, coupled with oil resistance.

REOPLEX 400: An unmodified type based on a special dibasic acid and glycols to give compatibility with polyvinyl acetate and cellulose acetate.

Table 1 gives some physical properties of REOPLEX polyester plasticisers.

REOPLEX POLYESTER PLASTICISERS FOR PVC

Compatibility

The two high viscosity (high molecular weight) unmodified types REOPLEX 100 and 110 are undoubtedly supreme examples of *compatability* combined with low volatility, resistance to migration and extraction. The corresponding unmodified polyesters based on adipic acid suffer from limited compatibility, as recently discussed by K. Zohrer and A. Merz (2). REOPLEX 220 is also fully compatible with PVC.

COMPOUNDING

Because of the low solvent power of REOPLEX 100 and 110, compounding temperatures of the order of 170°C are necessary both on the roll-mill and in the internal mixer. Such compounding is facilitated by pre-mixing with the PVC powder at around 60°C. The difficulties due to low solvent power are alleviated by the addition of a small amount of a simple ester plasticiser, e. g. 10—20% replacement, or by the use of mixtures with REOPLEX 220. The tendency of REOPLEX 100 and 110 mixes to stick to the roll-mill or calender is also reduced by the presence of REOPLEX 220 and by a small amount of REOMOL DOS. Standard lubricants or stabiliser-lubricants can also be used to overcome such tackiness.

For PVC paste work REOPLEX 100 and 220 can be used in the form of an organosol; aromatic hydrocarbons (e. g., xylene) must be used since these polyesters are not fully miscible with paraffinic hydrocarbons. REOPLEX 220 gives pastes of sufficiently low viscosity for most purposes, though the organosol technique can be applied here also.

VOLATILITY

The volatile loss from PVC compositions is very small with REOPLEX plasticisers. Some recently published figures (2) for loss in film weight at 105°C over 24 hours from films of 0.020" in thickness, containing 40 parts of plasticiser and 60 parts of PVC, are :

REOPLEX 100	0.48%
REOPLEX 110	0.71%
REOPLEX 220	0.90%

The corresponding figure for DOP is 3.7%

MECHANICAL PROPERTIES

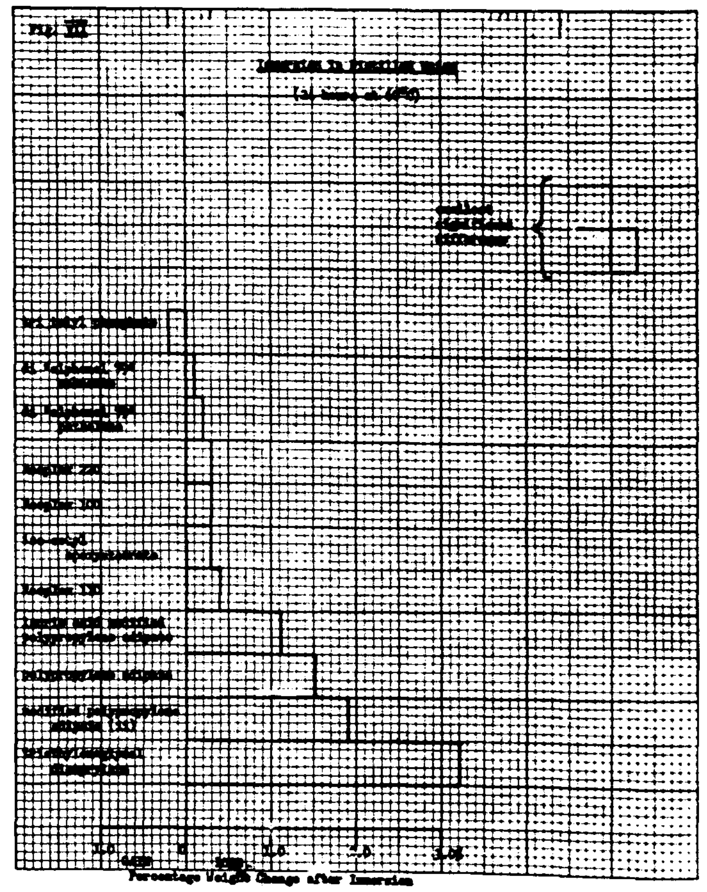
Table II shows a number of mechanical properties of PVC compositions based on REOPLEX 100, 110 and 220, compared with other well known simple ester plasticisers. The properties are given for three plasticiser concentrations, based on the following formulations in parts by weight :

PVC	70	65	60
plasticiser	30	35	40
white lead paste (7 : 1 in DOP)	5	5	5

The properties included in the Table are :—

100% MODULUS

This is the modulus (in psi) at 100% extension @ 25°C



BRITISH STANDARD HARDNESS NUMBER

As defined in British Standard 903/1950. Measured at 25°C.

T_5 TEMPERATURE

The temperature, in °C, at which the modulus of rigidity (torsional stiffness) reaches 1000 K/cm² (14,200 psi).

EFFECTIVITY QUANTITY

An average figure, obtained by taking the mean of four quantities, each of which is the percentage of plasticiser in the above type of formulation, which will produce a certain physical property at 25°C. The four standard properties are :

(1) modulus of 1000 psi at 100% extension
(2) B. S. H. No. 35
(3) torsional modulus of 600 psi
(4) creep (i. e. dead-load extension) of 50% in 30 secs at 500 psi.

Further details of the test methods will be found in the original literature (3, 4).

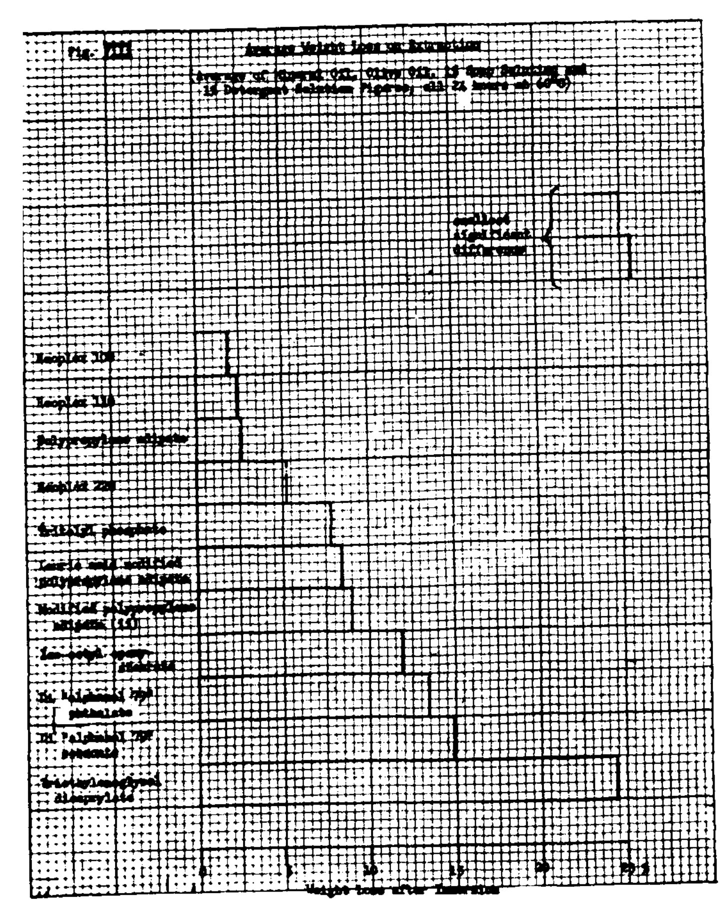
Effectivity quantities for all three polyesters are very little higher than those for the triaryl phosphates, and the low temperature behaviour of REOPLEX 100 and 110 is similar to that of the phosphates. REOPLEX 220 has better low temperature properties than the aryl phosphates, and in this respect is midway between these and the alkyl phthalates.

ELECTRICAL PROPERTIES

The volume resistivity of PVC compositions containing REOPLEX 100, 110 and 220, using the three formulations given above, is shown in graphical form in Fig. I, alongside similar curves for some diester plasticisers. The method of measurement is based on British Standard 903/1950. It will be noted that REOPLEX 100, 110 and 200 have excellent electrical properties.

MIGRATION

As already mentioned, the migration of polyester plasticisers is less influenced by the accepting medium than is the case with the simple diester plasticisers. A small influence can be noted, however, as will be seen in Table III, which is based on recently



published information. (2). This Table shows the % loss in weight of films 0.020" thick when in contact with the media stated for 24 hours at 20°C. The films contain 60 parts PVC and 40 parts of plasticiser. Dioctyl phthalate is included for comparison. (Table III.)

EXTRACTION BY LIQUIDS

Figs. II to VII show by means of block diagrams the loss in weight, when immersed in different liquids, of films 3" square and 0.007" thick, and made according to the 65/30 formula in the section dealing with mechanical properties. REOPLEX 100, 110 and 220 are compared with a number of different simple ester plasticisers and also three other polyester types, polypropylene adipate, lauric acid modified polypropylene adipate, and octanol modified polypropylene adipate. Fig. VIII shows the average of weight losses from all six types of immersion. Details of liquids mentioned and conditions of immersion are as follows :

petrol	75% toluene, 25% iso-octane; 1 hour at 25°C
mineral oil	Oil to specification D. E. F. 2001 ; 24 hours at 60°C
olive oil	B. P. quality ; 24 hours at 60°C
1% soap	1% solution of Lux flakes in distilled water ; 24 hours at 60°C
1% detergent	1% solution of triethanolamine lauryl sulphate in distilled water ; 24 hours at 60°C
distilled water	24 hours at 60°C.

After immersion, the weighed films are wiped clean and hung in a forced draught oven at 80°C for 1 hour, then wiped clean again and re-weighed.

The overall superiority of the REOPLEX polyesters can be seen especially from Fig. VIII. Polypropylene adipate gives a low average extraction figure since its inferior resistance to aqueous media is offset by its good resistance to petrol and oils. However its limited compatibility on storage must be borne in mind. As already indicated, tritolyl phosphate shows remarkable resistance to extraction considering that it is a simple ester plasticiser. In aqueous media, where sebacates, epoxystearates or tritolyl phosphates take first place, the REOPLEX types are still high in this assessment and are superior to other polyester types based on adipic acid.

REOPLEX POLYESTER PLASTICISERS FOR OTHER POLYMERS

Synthetic rubber

REOPLEX 100, 110 and 220 can all be used in butadiene-acrylonitrile and chloroprene polymers to control extraction by oil, but there is no significant contribution to low temperature properties. REOPLEX 300 is an excellent plasticiser for such rubbers and contributes to the low temperature performance coupled with resistance to oil extraction.

CELLULOSE NITRATE

Here again REOPLEX 100, 110 and 220 can be used, for example, in films and coatings, but REOPLEX 300 is more highly compatible and is a good solvent plasticiser. It is useful for leather finishes and is excellent as a plasticiser for cellulose nitrate-alkyd combination lacquers, e. g., the so-called " half-hour synthetics ". In such finishes flexible coatings can be achieved which are then resistant to polishes.

CELLULOSE ACETATE

REOPLEX 400 is manufactured from a dicarboxylic acid and special glycols to give sufficient polarity to achieve compatibility with cellulose acetate, including secondary, high acetyl and triacetate. Although compatible, REOPLEX 400 is not a solvent plasticiser and hence can be employed only in solvent systems, e. g., cast films and cable lacquers. It has better resistance to petrol, oil and water than di-methylglycol phthalate (di-2-methoxyethyl phthalate), the commonly used oil resistant plasticiser for cellulose acetate.

POLYVINYL ACETATE

REOPLEX 400 is a solvent plasticiser for PVA and can be incorporated in emulsions to give oil resistant films. It is also of use in adhesives as it does not migrate into paper and is non-blocking with the same medium.

APPLICATIONS

A number of uses for REOPLEX polyester plasticisers are given below. The reasons for them will be clear from the properties already discussed or mentioned here :

REOPLEX 100, REOPLEX 110 AND REOPLEX 220

PVC sheathing for radio-frequency cables.

PVC insulating and sheathing for high temperature cables.

PVC industrial protective clothing and gloves for resistance to extraction, e. g., in the chemical, oil, fish and other fatty food industries.

PVC conveyor belting for fatty materials.

PVC non-migratory and/or wash fast sheeting, e. g., for baby pants, hospital sheeting and water-proof bandages.

PVC self-adhesive film for wall, table and shelf coverings. Gives non-migration into adhesive and permits easy cleaning.

collar and cuff bands on PVC clothing of all types to prevent embrittlement due to migration into the skin.

PVC film and blown lay-flat tubing for packaging greased metal components, etc.

THE ABOVE AND REOPLEX 300

Butadiene acrylonitrile copolymers and chloroprene polymer rubbers for resistance to extraction by oils. REOPLEX 300 also conveys good low temperature properties.

Cellulose nitrate films and coatings. Especially REOPLEX 300 for " half-hour synthetic " finishes and other cellulose nitrate-alkyd combination lacquers.

REOPLEX 400

Non-solvent plasticiser for cellulose acetate films and coatings for resistance to migration and extraction.

Solvent plasticiser for polyvinyl acetate for emulsions and adhesives.

REFERENCES

(1) Selected Government Reports Volume I—Plastics. H. M. Stationery Office 1952.

(2) K. Zohrer and A. Merz, Kunststoffe, 1957, *47*, No. 3, 102-113.

(3) H. Jones, A. Hill and I. Williamson, Transactions of the Plastics Institute, 1950, *18* (July) 50-68.

(4) I. Williamson, British Plastics, 1950, *23* (Sept.) 87-90, 102.

TABLE I

PHYSICAL PROPERTIES OF REOPLEX POLYESTER PLASTICISERS

	REOPLEX 100	REOPLEX 110	REOPLEX 220	REOPLEX 300	REOPLEX 400
Viscosity (poises at 25°C.)	150 to 250	100 to 150	10 to 15	5 to 10	70 approx.
Density (g./ml. at 25°C)	1.06	1.07	1.025	1.02 to 1.03	1.17
Refractive Index (20°C)	1.468 to 1.469	1.477 to 1.478	1.463-1.465	1.459-1.461	
Acid Value (mg.KOH/g.)	5.0 max.	8.0 max.	7.0 max.	5 to 10	15 approx.
Colour (Hazen units)	300 max.	400 max.	350 max.	400 to 500	750 approx.

TABLE II

MECHANICAL PROPERTIES OF PVC COMPOSITIONS

	100 MOD. PSI			B. S. H. No.			EFFECTIVITY	T_3 TEMPERATURES		
PLASTICISER	30pph	35pph	40pph	30pph	35pph	40pph	QUANTITY %	30pph	35pph	40pph
Reoplex 100	2280	1735	1180	11	24	35	41	+ 16	+ 8	— 1
,, 110	2530	1950	1335	9	20	38	42	+ 23	+ 8.5	+ 1
,, 220	2040	1335	980	16	25	36	40	+ 15	— 1	— 11
Dioctyl phthalate	1650	1040	697	22	34	46	36	+ 2.5	—10	— 22
Di "alphanol 79" phthalate	1590	910	670	26	37	47	35	— 1	—15	— 27
Di-iso-octyl phthalate	1580	1280	754	23	32	46	37	+ 3	— 5	— 22
Dicapryl phthalate	1610	1080	670	22	34	44	36	+ 4	— 9	— 22
Dioctyl sebacate	1210	826	598	22	34	43	35	— 14	—36	— 47
Di "alphanol 79" sebacate	1100	868	570	21	30	41	36	— 14	—32	— 42
Di-iso-octyl sebacate	1320	925	655	20	29	41	36	— 11	—32	— 49
Tritolyl phosphate	2150	1335	855	16	35	50	37	+ 17	+ 7	— 1
Trixylyl phosphate	2250	1520	910	10	28	41	39	+ 20	+13	+ 5

TABLE III

MIGRATION FROM PVC COMPOSITIONS

Migration into.	REOPLEX 100	REOPLEX 110	REOPLEX 220	DOP
Cellulose nitrate	2.7	3.4	9.1	14.1
Leather	—0.5	0.3	4.5	6.8
Rubber	2.9	2.4	0	11.0
Polyethylene	0.1	0	0.3	2.2

COBLAC 405 for Jet Black Nitrocellulose and Acrylic Lacquers

(SPECIALLY CONTRIBUTED TO JOIE, BOMBAY)

COBLAC 405 is a complete colloidal dispersion in dry chip form containing 22% NEO SPECTRA MARK II Carbon Black, ½ second nitrocellulose and plasticizer. To produce a jet black lacquer, it is only necessary to dissolve the COBLAC 405 dry chips in a clear lacquer solution.

The outstanding feature of this product is its very high carbon black loading and high jetness, gloss and surface smoothness imparted to nitrocellulose and acrylic lacquers.

COBLAC 405 was developed with two specific factors in mind :

1. Economy : Higher black loading means lower cost per pound of dispersed carbon black.

2. Dispersions of carbon black in nitrocellulose have provided a means of pigmenting acrylic lacquers but the amount of nitrocellulose carried into the acrylic lacquer was excessive. COBLAC 405 with its higher carbon black content means appreciable less nitrocellulose carried in and lowers the nitrocellulose to a level which can be tolerated in acrylic lacquers.

Acrylic lacquers made from COBLAC 405 can contain as low as 12% nitrocellulose based on the lacquer solids. Tests have definitely shown that this low amount of nitrocellulose enhances the hardness, jetness, and gloss of acrylic lacquers.

COBLAC 405 COMPOSITION

	Per cent by weight
NEO SPECTRA MARK II Carbon Black	22
½ second nitrocellulose	59
Plasticizer—Dibutyl Phthalate	19
	100

HANDLING

The way in which COBLAC 405 is dissolved is vital to the successful utilization of the qualities available in this product. The method of handling also determines the ease of solution. There naturally must be a certain time factor for the swelling and solution of a dry chip nitrocellulose. This can be reduced to a minimum by careful regard to the processing.

The first principle is the well-known one that the smaller the particle being dissolved, the faster is the rate of solution. The COBLAC 405 chip is small enough to take advantage of this factor and a single chip will rapidly dissolve the solvents. However, when a mass of chips is to be dissolved, the problem becomes greater since in a solvent the surfaces of the chips become tacky and stick together, building up one or more large lumps which are slow of solution. This must be avoided.

METHOD # 1

The best method is the single stage solution. It consists of making a clear solution in the mixer of all the ingredients in the formula except the chip. With continuous agitation the chips are slowly added. The body of the clear is such as to hold the particles apart and prevent their sticking together. The chips go into complete solution in a relatively short time. This method involves only one operation and should be used whenever possible.

METHOD # 2

Another suggested method of solution is to keep the ratio of COBLAC 405 chip to clear high. This method takes advantage of a viscous solution which will tend to pull the chips apart faster.

As solution takes place, more clear can be added to control viscosity. The higher the speed and the greater the power input of the mixing apparatus, the quicker will be complete solution. Excessive agitation and whipping of air into the system will cause flocculation and a drop in color.

If possible straight solvent solution should be avoided. Cutting a chip with thinner before adding the other ingredients of the lacquer is a very risky procedure. A highly concentrated carbon black dispersion with low binder content can stand very little dilution with straight solvent before reaching a point where the binder is so reduced in viscosity that it can be thought of as having been washed off from the dispersed pigment particles, thus allowing the attractive forces between those particles to take over and induce flocculation. If instead the chip is dissolved in a solution of the binder, the dispersed particles remain insulated from each other and the full benefit of the excellent dispersion in COBLAC 405 is maintained.

SUGGESTED STARTING FORMULATION FOR JET BLACK NITROCELLULOSE COBLAC 405 LACQUER

Put into mixer :

Ethyl alcohol	1.5 lb.
Ethyl acetate	9.0 lb.
Butyl Acetate	15.0 lb.
Butyl alcohol	6.0 lb.
Toluol	30.0 lb.
Blown castor oil	2.5 lb.
Dibutyl phthalate	2.5 lb.
Short oil non-oxidizing alkyd (60% solids)	11.5 lb.
½" nitrocellulose (30% alcohol by wt.)	15.0 lb.

Agitation until nitrocellulose is completely in solution.

While under agitation add :

COBLAC 405	6.7 lb.

Continue with thorough agitation until COBLAC 405 is completely dissolved.

Final step centrifuge. Lacquer is now finished.

SUGGESTED STARTING FORMULATION FOR JET BLACK ACRYLIC LACQUER

Put into mixer :

Ethylene glycol monoethyl ether acetate	54.5 lb.
Methyl ethyl ketone	35.0 lb.
Toluol	10.5 lb.

While under agitation add :

Butyl benzyl phthalate	1.0 lb.
Acrylic resin 100% solids	14.5 lb.

Agitate until acrylic resin is completely dissolved.

Next add :

COBLAC 405	4.5 lb.

Continue with thorough agitation until the COBLAC 405 is completely dissolved.

Centrifuge—Lacquer is now complete.

This lacquer contains 20% solids.

MANUFACTURING ADVANTAGES

The use of COBLAC 405 eliminates all grinding problems. It is to your advantage to have carbon black come to you already dispersed and thus be in a better position to concentrate on other problems. The chips are clean and free from all undispersed black—result, no labor complaint—no dry carbon black to handle.

An elaborate system for sampling and testing of COBLAC 405 has been devised. Each drum carries a pass slip personally signed by the man in charge, verifying the quality of the product. Years of operation have proven this system successful.

WATERLESS BORING

In the Central Asian Republics and in some other regions of the USSR, where nature has not endowed the earth with natural reservoirs, artesian wells are becoming increasingly popular. But in order to drill them by the old rotor method with the aid of an argillaceous solution, water is required. This task is hard to solve in a waterless terrain.

M. Kerchensky, a Soviet engineer, developed the first Soviet rotating head for rotor drilling of artesian wells without water. The bits are cooled and the broken rock is brought out by air fed under high pressure.

The new head accelerates the drilling by 50 per cent.

PLASTICS IN WORKSHOPS

By Asoke Chandra Bhattacharya, A. M. I. Prod. E.

TO most people, plastic means something widely used in the manufacture of toys and similar small articles of day to day use or as pack-aids. Although this was so to begin with, but its field of application has in the course of time increased to a great extent.

Originally conceived as merely a war-time substitute of certain natural raw materials then in critical short supply, it has now developed into quite a large industry through the astounding developments in applied chemistry.

With this phenomenal development brought about by the fruitful and pioneering research activities by scientists and technicians in the universities and leading factory establishments, it has become possible now to produce the plastics in almost any specification desired. As a result of this achievement, plastic to-day is not only being used as a material for the production of various articles, but that it is also assisting in the production of many others in Workshops and bringing about revolutionary changes in the current production techniques. The followings are some of the typical examples.

PLASTIC DIES

Dies made from plastic are in use in the aircraft industry and it is only recently that they have been applied in the motor car industry for the production of experimental and prototype stampings.

The dies for such stampings are being made from a non-shrinking thermo-setting phenolic resin. This plastic has exceptional dimensional stability and freedom from distortion. Due to this reason close tolerances can be maintained and oversize patterns with shrinkage allowances are not required.

The chief advantages of making dies from plastic are that since they can be cast to close tolerances, little finishing is required. Developments for the draw can be established when plastic dies are employed and correct design ensured before the permanent steel dies are made. Alterations or repairs to plastic dies can easily be made by taking off extra material or casting additional resin directly on the punch, die or draw ring. The last but not the least is that plastic dies are light in weight and relatively easy to make.

The largest plastic die made so far is employed to produce motor car body pressings 64½" long by 66½" wide by 9" deep from steel blanks 0.042 in. thick. Plastic dies are generally held either in a welded steel frame or an equivalent volume of plastic. The modern practice is however to use kirksite (zinc alloy) for the purpose.

For the purpose of making the die, the plastic is mixed cold and is readily poured without pressure, into the moulds. When cured at suitable temperature, the plastic becomes insoluble and cannot be re-softened. The cured material has a hardness of 110 Rockwell R, a compressive strength of 11,000 lbs. per Sq. in. and a tensile strength of 5,000 lbs. per sq. in. It weighs 0.045 lbs. per Cu. in.

Patterns for the plastic dies are usually made from wood or plaster. Metal patterns can also be employed. After developing the binder line and necessary run offs, by means of conventional methods, a plaster mould for the plastic punch is cast directly against patterns.

PLASTICS IN FOUNDRY

Full advantage of the intrinsic properties of thermosetting plastics are now being availed of in the use of synthetic resins to bond sand for making solid foundry cores. Techniques used include high frequency heating and, more recently, blowing of resin-sand mixture into a heated corebox. The rheology of resin-bonded sands has been investigated and the results obtained are assisting in overcoming core-blowing problems.

The advent of non-segregating (pre-coated) resin-bonded sand has made possible the coming of hollow-shell cores with many advantages over solid cores, into prominence as an offshoot of the shell-moulding process.

The shell method itself, which provides a new technique for making foundry moulds and cores, owes its origin to the heat hardening properties of the phenolic resin binders. Resins used for this purpose are almost entirely of the phenolic type, but include both resoles and novalacs with hexamine.

Among the smaller applications of plastics in foundry work is the use of thermosetting resins for improving the surface of conventional "green sand" moulds and so obtaining better casting finish.

REINFORCED PLASTICS

The modern workshop uses of fabric-reinforced plastic materials are becoming increasingly numerous. As a material for the production of non-metallic bearings, it is now gaining increased favour because of the following advantages :—

(a) Reduced friction is set up between this material and the usual steel of the bearing, the frictional co-efficient of such a rubbing contact being even less than it is in the case of a Babbit metal bearing. This brings about a reduction in driving power, which for heavy machinery, is an important considera-tion.

(b) The average wear-resistance of a fabric-resin bearing is at least ten times greater than that of a normal plain white-metal bearing or even of a Babbit bearing one major disadvantage, which such bearings suffer from, is the very low thermal conductivity of the plastic material.

Considerable use of this material is now being made for the production of gears and pinions of various types. The greatest advantage of these Wheels is that they give a more or less noiseless running and, at the same time, reduced friction.

Macerated mouldings have made possible to obtain the wheels of light trucks and similar workshop rolling-stock. These wheels do not cut wooden floors, neither do they indent or "rut" asphalt floors or abrade surfaces of cement, concrete, composition or other flooring material. They are more silent in running than the ordinary metal or metal-tyred truck.

MOULDED NYLON

Nylon, which is well known as a textile fibre, is now making its mark as a moulded plastic for widespread use in textile machinery, automobile industry etc., and competing with steel, brass, copper and other metals.

The moulded nylon parts compare very favourably in price with metal items which require individual machining operations. This is particularly noticeable in the case of moulded nylon gears. Where intricacy of form is involved, as for complex gears, a great saving is made by moulding compared to what it would have been to produce them by machining.

There is little doubt that there is an application for plastics in practically every workshop and the time is not far when this material will become a major aid for shot-cut to higher production.

WITH THE AID OF INFRA-RED RAYS

A. Malnev, scientific worker of the Institute of Physics of the Ukrainian Academy of Sciences, has proposed a new method of determining the amount of oil in oil-products based on their absorption of infra-red rays. A special instrument—infra-red spectrometer—has been designed for this purpose. The core of the instrument is a bolometer, a highly sensitive receiver of infra-red, invisible heat, rays. It is capable of reacting to changes in temperature expressed in 0.000001 degree. Despite this high sensitivity the instrument can work in a room where the temperature varies within the limits of 15 to 30 degrees of heat.

Progress of the Plastics Industry

DOW TO MAKE LINCEAR POLYETHYLENES

Dow Chemicals, U. S. A. are planning to put up a plant at its Bay City, Mich., division, described as a "multimillion-dollar" production unit. It will use the Ziegler process.

One of the early Zieglar licencees, Dow has been piloting the process for two years, plans to make a major effort in the field.

FILM FROM TEFLON

Du pont will make film from Teflon 100-X., its experimental Teflon resin. Sample quantities of the new film will be available as soon as the company completes its plan. It is presently building semiworks units for making the resin.

Du pont sees the new product as complementing its line of industrial and packaging films (e. g., Mylar Polyester, Cellophane). It points out that the fluoro-carbon version will always be more expensive than, say Mylar. But it sees the film as carving a niche for itself because it is able to withstand high temperatures (400°F under continuous service) and because of its good electrical applications look promising, Du Pont says, its film should also find work as a tank liner and in specialized container applications where Teflon's recognized corrosion resistance will be important.

Du Pont's production facilities for the 100-X will not be completed until 1959.

THE POLYTHENE OUTLOOK

If all the capacity planned to be in production by 1960 is utilized, the U. S. will be able to produce resin at a 1-billion-lbs./year rate—and 30% of the total will be of the newer high-density material. That is the picture lined out at the week-long ACS meeting in New York by Aries Associates' Robert Aries and David Dworkin.

Actual production three years hence, however, they indicated, will probably be about 760 million lbs., with 18% of the total being high density. U. S. production is expected to climb to some 1.1 billion lbs. by '62, with high-density polyethylene accounting for approximately 39%.

And how will the two types fare in garnering markets? Here's the Aries' rundown of a probable '62 end-use pattern giving the estimated share (in million pounds) for the older and the new type of polyethylene :

End-Use	High	Low
Moulded articles	120	100
Electrical	45	75
Film	100	250
Pipe	30	110
Paper coating	35	55
Bottles, tubes	25	75
Fibres	25	—
Miscellaneous, exports	60	40

The chief problems facing the industry, Aries pointed out, is how to sell the output of present—and upcoming—polyethylene facilities. By '58, there may be at least eight commercial producers of low-pressure polyethylenes, in addition to nine current makers of high-pressure material. At least seven other companies are reportedly doing development work aiming toward low-pressure poly production.

A PLASTIC HOT WATER PIPE

The development of a plastic hot water pipe has long been a target for researchers.

In this connection claims are advanced by U. S. Rubber that its newest styrene-butadiene-acrylonit-rile resin (Kralastic HTHT) brings this prospect closer. The high-temperature, high-tensile material was revealed recently at the dedication ceremony of the company's new Research Centre in Wayne, N. J.

Lack of heat resistance was the major obstacle to any all-out plastics assault on the lush hot water pipe market now held firmly by metals, and, though U. S. Rubber's claims are cautious, the new resin appears to be a significant breakthrough. The material is in production at the firm's expanding Baton Rouge, La., plant.

POLYETHYLENE PLANT OF GRACE

The first two weeks of successful running have been completed by the new high-density polyethylene plant that the polymer chemicals division of W. R. Grace & Co., New York, has just completed in Baton Rouge, La. Delivery of the product, called "Grex", will soon commence.

The new plant with an annual capacity of 50 million pounds is the largest plant of its kind in the world to come on stream as an integrated operating unit. It is also the first polyethylene plant to be built in Louisiana, Grace reported.

The plant, built by the Fluor Corporation, Ltd., Los Angeles, was under construction for less than fifteen months. The overall investment in commercial plant, research and development facilities exceeds $ 18 million.

POLYESTER FOAM RESINS

A series of unique low-cost polyester foaming resins said to possess superior characteristics for the manufacture of urethane foamed products has been developed by Pittsburgh Plate Glass Company, Pittsburgh, Pa., and will be immediately added to the company's regular line of foaming resins.

US RUBBER TO ENTER POLYETHYLENE YARN FIELD

United States Rubber Company, New York, will enter the polyethylene yarn business as a producer and seller before the end of the year. This will be the first time the company, which has been in the textile business since 1917, has become a producer of plastic yarns.

The new yarn will be produced at Providence, R. I., in a plant of the company's footwear and general products division. The textile division will be responsible for sales. Sales headquarters will be at 1230 Avenue of the Americas, New York.

The company said it decided to enter the polyethylene yarn business because its market research studies had convinced it that this business has tremendous growth potential, and that there will be room for another manufacturer of top quality polyethylene yarns.

PLASTICS DEVELOPMENTS IN HUNGARY

Nearly half of the 137-mile Rumanian section of the pipeline to carry natural gas to Hungary for the plastics industry has now been laid down. It is expected that the last delivery of pipes to the Rumanian section will take place next spring. Work on the 83-mile Hungarian section will start this year. The pipe will carry 200m. cubic metres of gas annually from just outside Bucharest to Tszapalkonla, northeast Hungary, where the chemical combine which will use it mainly for making PVC and polyacrylonitrile is situated. Construction will be completed this year of the new section of the Hungaria Chemical Works which will produce polymer for the manufacture of nylon yarn. A plant to produce 200 lbs. of polyethylene daily is near completion in Hungary.

ROT-PROOF FLEXIBLE BRITISH PIPELINE

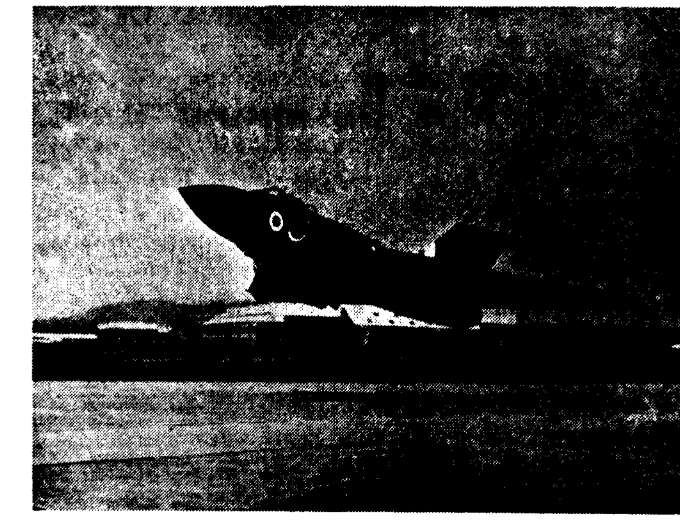
Designed to meet the stringent demands of tropical climates, a new flexible pipeline has been introduced by British industry. In addition to being flexible, it is also portable and requires little or no maintenance. Known as BTR "Plastidry", the pipeline comprises PVC lining and covering fused on to synthetic-fibre reinforcing-material, forming a plastic mass of great strength and wear-resistance.

The pipeline is claimed to be completely rotproof and requires no drying. Another advantage is that i coils flat; and an even more important one, from the tropical viewpoint is, that it is immune tc attack by rodents, insects, and fungi, and may b laid in any terrain or stored anywhere withou detriment.

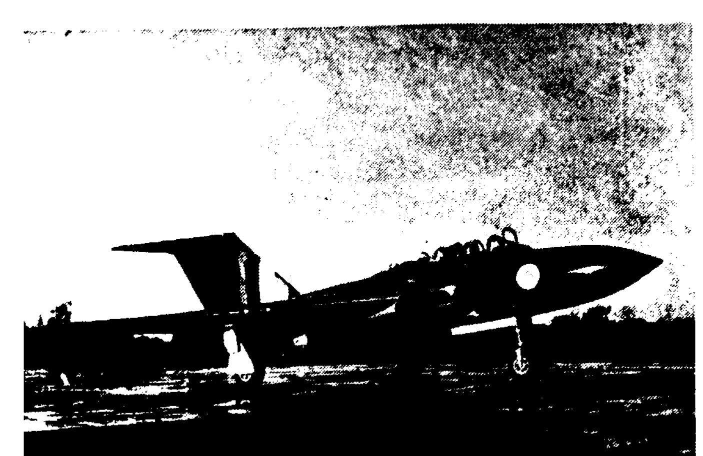
This new flexible pipeline was designed primaril for irrigation purposes, and is the only hose of th flat-coil type which can be exposed to strong sunligh for prolonged periods without suffering appreciabl deterioration in strength.

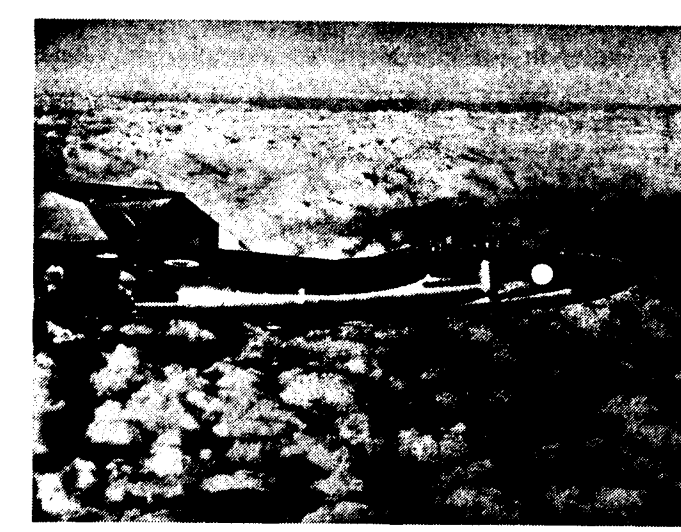
It is also claimed that any kind of water—even sal or industrially polluted—can be conducted throug the new pipeline without harming it. The Plastidr hose is also suitable for conveying fertilizing or crop spraying fluids.

The flexible hose is being made available in varyin diameters, from 1½ in. to 6 in. Lightness in weight also a feature. And in the event of damage, tl flexible pipeline can be simply and effectively repaire



AVIATION SUPPLEMENT





The Designing and Testing of Aero Tyres

By P. D. Patterson, A.I.R.I.,
Technical Writer,
Dunlop Research Centre

IN the early days of flying, aircraft were very light and landing speeds so low that it was possible to land on wooden skids. These were later superseded by bicycle tyres and eventually by the motorcycle tyres of that time. Another rubber product also rendered assistance, in the form of a shock absorber made from rubber cord in tension. The weight and landing speed of early machines then began to increase and in 1913 the first tyres specially made for aircraft use appeared.

These early aircraft tyres had an overall diameter of some 26", with a cross section of about 2½", and were entirely made by hand on a "one-off" basis. Since then aircraft characteristics have, of course, changed very considerably and have called for continuous progress in the design of suitable tyres.

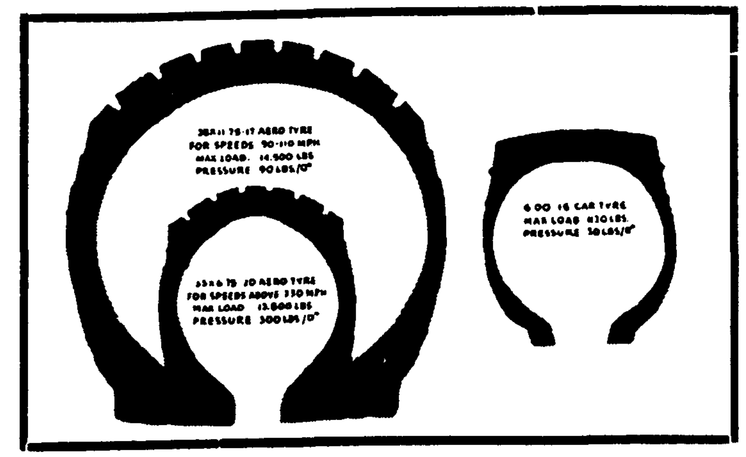
PNEUMATIC TYRES ON AIRCRAFT

The main function of the tyre and wheel is to make it possible for the aircraft to be manœuvred on the ground, to cushion irregularities in the surface and to allow the aircraft to take-off and land. Solid rubber tyres are, of course, quite unsuitable, because of poor shock absorption, excessive weight and high ground contact pressure.

In the last few years the rapid progress in aircraft design (with comparable developments in runway construction) are bringing about substantial changes in the design of aero tyres. The modern high speed jet aircraft brings out clearly the influence of aircraft development on tyre design. The thin wings of these aircraft mean that the space into which the wheels can be retracted is very restricted, so that the tyres themselves have to be much smaller. At the same time, higher take-off and landing speeds and higher aircraft weights impose considerably greater stresses on these smaller tyres. Generally speaking, the tyre designer is attacking these problems by constructing smaller tyres operating at higher pressures. This, of course, means higher impact loads on the runways, but modern surfaces have been able to cater for them up to the present.

An operator at the control panel during a typical test. The tyres concerned can be seen through the safety glass wall, surrounded by steel torpedo netting as a further precaution.

		Tyre for piston-engined fighter	Tyre for current-type of jet fighter	Possible tyre for future jet fighter
Inflation Pressure (lbs. per sq. in.)	..	75	160	250
Relative cross-sectional width	..	100	65	54
Relative overall diameter	..	100	85	78
Tyre weight (lbs.)	..	49	32	24



This photograph shows two sections from modern aircraft tyres designed to carry loads of about 6½ tons, compared with a car tyre designed for a maximum load of ½ ton. It indicates clearly the considerably greater stresses which the modern aro tyre has to carry.

The modern trend in aero tyre design is shown in the following table, comparing tyre characteristics for three aircraft of the fighter type, the tyres carrying a load of about 3½ tons in each case.

It is not enough simply to reduce the tyre size and increase the tyre pressure, because the smaller and harder tyre must still deflect enough to give the necessary shock absorption; it also has to stand up to higher internal stresses, resulting from increased impact loading and higher rotational speeds when taking off or landing.

TESTING AERO TYRES

Every endeavour is naturally made to get as much information as possible about tyre performance by studying their behaviour in service. However, this information takes a long time to collect and analyse. It may also be rather difficult in the case of very new designs, to carry out extensive service tests on a prototype tyre.

Several types of indoor testing machines for aero tyres have been in use for many years past and the illustrations (on page A.4) show one of them. This is a machine where the tyre is pressed under load against a rotating drum, the surface of the drum having a double camber, so that the tyre is rocked from side to side as it rotates. This machine simulates sideways force in landing and is a severe test on the bead construction.

Other standard machines for testing aero tyres include rotating drums without camber, impact machines where a spiked tool is dropped onto the tyre from a great height, and machines which can record the load-deflection behaviour of an aero tyre when struck a blow, at temperatures down to—75°C.

The intensified service conditions resulting from the rapid progress in aircraft design have made it necessary to design testing machines to simulate these extreme conditions.

To get a clear picture of tyre performance under these strenuous circumstances and to obtain the information quickly under controlled conditions, a test machine capable of reproducing the principal happenings is clearly essential, both to supplement existing machines and to confirm service information. A new machine designed exclusively for the high speed testing of aero tyres, has recently been installed in its own test building at Fort Dunlop, U. K.

NEW HIGH SPEED TESTING MACHINE

This machine is unique, in that its power is provided by a Rolls Royce Merlin aero engine having a maximum power output of over 1700 h. p. The transmission gearing has been specially modified so that the "driven" tyre (nearest the camera in the general view of the machine) is rotated at crankshaft speed. With the larger tyres to be tested, this gives a surface speed of up to 300 m. p. h. In order to simulate the effect of a loaded tyre travelling over a flat surface, the driven tyre has another freely-rotating tyre (called the "idler") pressed against it by means of a pneumatic ram.

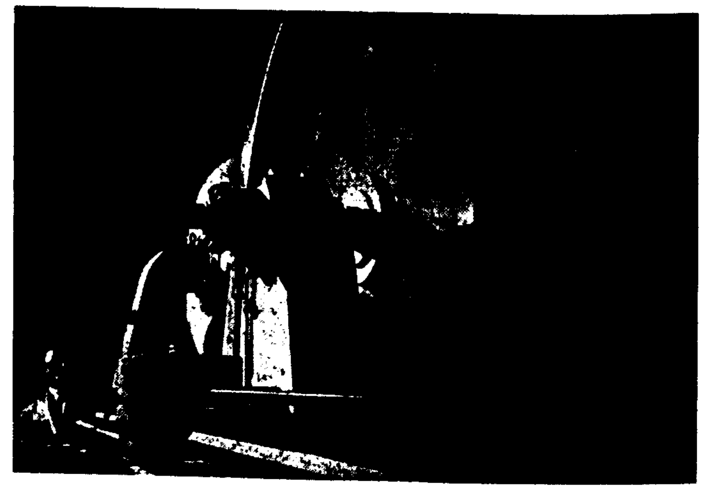
The photograph of the machine itself in the main test building, shows the "idler" tyre (the one furthest from the camera) mounted in a horizontal saddle or fork which can be moved forward by a pneumatic ram to make contact with the driven tyre. The driven tyre is regarded as the ground for test purposes and the "idler" tyre can be pressed against it at loads up to 7½ tons. This load is obtained from a continuously running air compressor, which is part of the plant.

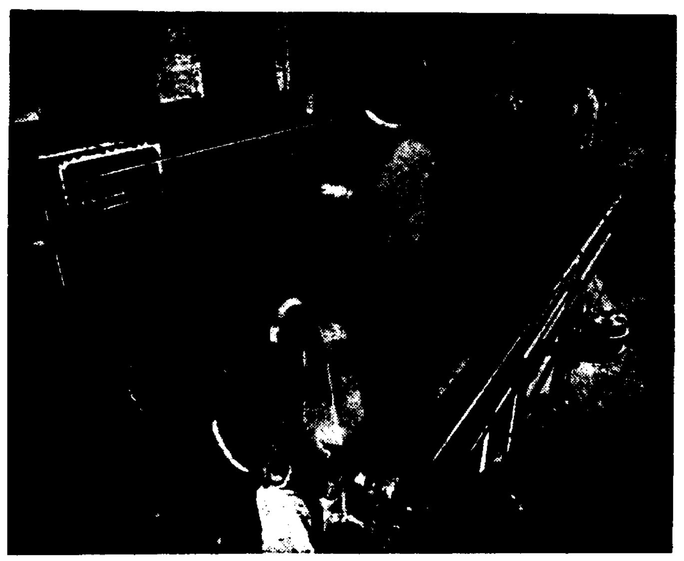
This outwardly simple arrangement of one tyre running against another calls for very complex control gear. The Merlin engine itself was never designed for running on a test bed and many modifications to its accessories (such as fuel supply, cooling, oil circuits etc.) had to be designed, with all the necessary

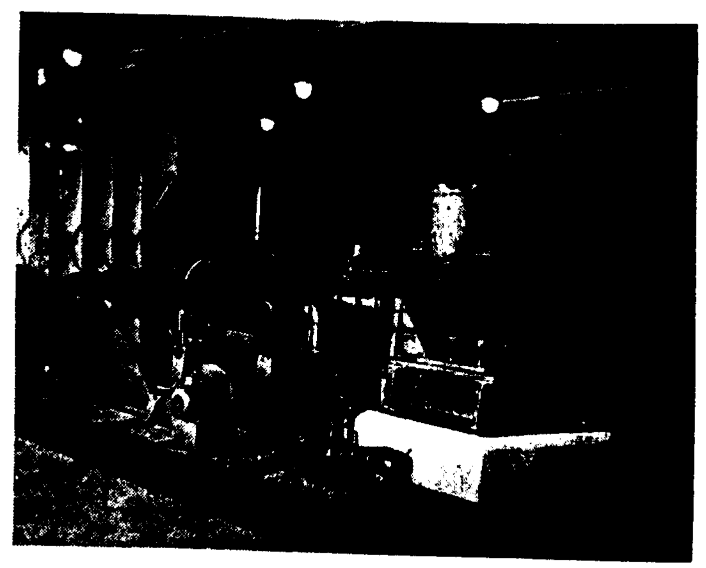
Right: A close view of the High Speed double camber machine when stationary, showing the loading beam.

Below Left: The large double camber machine in motion.

Below Right: A view inside the main test room of the new high speed testing plant for æro tyres. On the right are the tyres being tested and on the left the Merlin æro engine driving through special gearing and with special cooling arrangements.







indicators on a control panel. Control of the tyre test schedules themselves added further complications, calling for an elaborate control gear of their own.

During testing, the supervisory staff are positioned in a separate control room which is divided from the test room by a wall of double thickness safety glass. Automatic timing equipment enables test cycles to be reproduced with close accuracy. This is particularly important when tyres are put through a landing cycle, i. e. initial approach bump, quick retraction to simulate bounce or " float ", and a final reloading of the tyre for the run down to rest. Other controls govern the rate of loading or unloading of the tyres, so that they are fully loaded at the end of the landing cycle or just coming out of contact by the end of the take-off cycle.

It can thus be seen that with these facilities at their disposal, tyre designers can study most of the problems associated with the performance of present and prototype high speed aircraft tyres.

SPECIAL FEATURES

A modern tyre is a complicated structure, so that calculating the forces at work inside it is difficult. In many ways the theoretical calculations are based on earlier experience and one of the immediate uses for the test machine described will be to prove that these calculations are, in fact, correct.

Many other special problems are studied, which can only be dealt with on a machine of this kind, where optical, electronic and photographic equipment can be

used to make detailed observations, while tyres are running under simulated service conditions.

Centrifugal growth is one of the factors which warrants special study. It is interesting to see a tyre, inflated to a very high pressure, getting appreciably bigger as the running speed is increased. However, some growth must be expected, when it is realised that the centrifugal force on a relatively small but flexible tyre is of the order of 100 tons at 300 m. p. h.; this has the effect of roughly doubling the stresses in the tyre casing from inflation pressure. The aero tyre designer must be sure that centrifugal growth is limited, so that there can be no risk of tyres fouling the undercarriage or the storage compartment.

The tyre designer is aided in his efforts by the increasing availability of new types of rubber, compounding ingredients and synthetic textiles. He is particularly helped by the availability of modern test machines such as the one described, which play an essential part in providing the aircraft industry with tyres which will give the required performance under the most arduous conditions.

(Courtesy: " Dunlop Gazette ")

Evaporation Cooling in Metallurgy

Metallurgy is justly regarded as the chemistry of high temperatures. Blast furnace operators and steel smelters constantly attempt to improve heat resistance of furnaces and safeguard them against burn out.

One of the most effective methods in this sphere is evaporation cooling. It is successfully being used now in the open hearth furnaces of the Kuznetsk, Magnitogorsk, Zlatoust, Makeyevka, Voroshilov, Chelyabinsk and other metallurgical works. As a result the durability of the cooled furnaces has been considerably improved, furnace repair-stoppages have been cut, output of metal has increased and working costs lowered.

Besides this, evaporation cooling provides the metallurgists with wider opportunities in using oxygen for the further intensification of furnace processes while considerably cutting down fuel expenditure. Hot steam, resulting from the water cooling of open hearth furnaces, is not lost—it is used for improving the work of various heat and power installations.

Evaporation cooling has resulted in a 2—2.5—fold increase in the fuel utilization coefficient of open hearth furnaces. Hundreds of thousands of tons of masout have been economised.

More than 60 open hearth furnaces as well as several blast and heating furnaces will be outfitted with evaporation coolers in the course of this year.

* * *

SEMI-CONDUCTOR RADIO VALVES

This radio valve in its simple small paper wrapper strikes one as something unusual. It is a 20 mm metal capsule weighing some 3 grams. Semi-conductors account for the unusual shape of the valve. Thousands upon thousands of such miniature semi-conductor articles are at present manufactured by the Svetlana Plant in Leningrad.

The department producing new radio valves is one of the plant's youngest. The commercial production of planar germanium triodes, as these valves are called, was started here only six months ago.

During this period the production increased 7-fold.

Mass production of the new " P—6 " semi-conductor triode will start during the second quarter of this year. Its design is more reliable but at the same time it has less parts.

The semi-conductor radio valve department is picking up speed. A seven-fold increase in output over a short period is the result of a creative approach to production.

Here is a machine for cutting germanium. Fitter I. Fedorenko increased both the number of bands cutting germanium and the machine's speed. Labour productivity increased four-fold. I. Fedorenko together with section head V. Koverznev designed a machine for the mechanical polishing of germanium crystals. Engineer G. Merkulova elaborated the technology of the production of improved high-quality triodes.

Many similar examples could be cited. The modernization of plant equipment has resulted in cutting by half the amount of labour spent in manufacturing semi-conductor radio valves. The expenditure of germanium per 1,000 valves has been cut almost by half.

New Aircraft Starting System

By

The British Thomson-Houston Co. Ltd.

BTH Liquid Fuel Starter to be fitted to latest " Javelin " aircraft.

A new starting system, simpler and lighter in weight than any previous system, and using the monofuel iso-propyl nitrate (i. p. n.) has been developed by BTH. Following satisfactory tests on the starter fitted to the new Armstrong Siddeley ' Sapphire ' turbo-jet engine, the Ministry of Supply has placed orders for its use on the latest Gloster ' Javelin ' aircraft, the world's first delta-wing all-weather interceptor fighter, which flies at heights of over 50,000 feet and with a speed between 600 and 700 m. p. h.

EARLY DEVELOPMENT

Since the Second World War and the almost universal adoption of the gas-turbine engine for fighter aircraft, there have been many starters developed in which gases under pressure are used to turn a small high-speed turbine wheel connected to the engine through gears. Although not generally known, this form of starter was pioneered by British Thomson-Houston at its Coventry works as far back as 1937. The starter was successfully used and flight tested on Bristol ' Hercules ' engines. Starters of this type were also made for the Pobjoy ' Niagara ' engine, and the Rolls-Royce ' Merlin ' engine, but the intervention of the war prevented further development until the gas-turbine engine was introduced. The characteristics of the turbine type starter are eminently suitable for starting gas turbine engines, and since the war BTH has built many thousands of this type of starter. In these starters the gases under pressure have been provided by a cartridge.

From the very first it was realized by BTH that the use of a cartridge had very definite limitations, and it is interesting to note that even in the early days consideration was given to the use of the aircraft engine fuel to provide the gases for the starter. Unfortunately, such fuels require air in fairly large quantities, and the provision and storage of this air in an aircraft is the major disadvantage of all forms of air/fuel or other starting systems requiring air storage.

The Government, however, was quick to appreciate the potentialities of a liquid fuel starter which would require no additional air, and through I. C. I., encouraged the development of the monofuel iso-propyl nitrate.

THE NEW BTH STARTING SYSTEM

In the BTH i. p. n. starting system the fuel is decomposed by a combination of heat and pressure only. In its earliest forms the system required electrical power to pump the fuel to the starter, and to provide the pressure and also electrical power to provide heat. Thus, in common with other forms of i. p. n. starter, a considerable electrical current was required during the starting cycle. This is a very great drawback on fighter aircraft where it is desired to keep the size of aircraft battery to a minimum. In the latest BTH system the starting current required is *less than 1 ampere per start*, so that in a multi-engined aircraft all the engines can be started simultaneously without a heavy demand from the aircraft battery. In addition, because of its simplicity the new BTH equipment is approximately 30% lighter in weight than that incorporated in any other starting system.

The heart of the new system is a fuel injector which acts rather like a liquid fuel cartridge. This comprises a cylinder containing enough fuel for one start, and a spring-loaded piston. The start is initiated by a small cartridge (50—60 gm.) which is mounted in an accessible position remote from the starter itself. The cartridge is fired into the starter combustion chamber, and provides heat and pressure. The pressure acts behind the piston in the injector and starts the flow of fuel to the starter chamber. Subsequent decomposition of the fuel in the chamber maintains the pressure to complete the full stroke of the injector. After the start is completed the injector recharges itself by the return of the piston. Because the cartridge pressure is low the initial engagement of the coupling mechanism between the starter and the engine is gentle, being made before

(Continued on page A.8)

CIVIL AVIATION IN THE UNITED KINGDOM

From an Aeronautical Engineer

RESPONSIBILITY for the general development and supervision of United Kingdom Civil Aviation rests with the Minister of Transport and Civil Aviation. [1]

Scheduled public air transport services are reserved to the two public corporations—British Overseas Airways Corporation (BOAC) and British European Airways (BEA)—and their associates. Scheduled services are those operated regularly or systematically between two places, one of which is in the United Kingdom, for the transport of passengers, mail or cargo for remuneration, in such a manner that each flight is open to use by members of the public. Non-scheduled or charter flights are operated in the main by independent air transport companies, although the Corporations undertake such flights as opportunity offers with aircraft not required for their scheduled services at any particular time. Some of these independent firms have large fleets of aircraft and many of them operate scheduled services as associates of one or other of the Corporations.

I. EARLY DEVELOPMENT

British airmen were among the first to carry mails (at the time of the Coronation of H. M. King George V in 1911) and the first to operate regular mail and passenger services. The actual inauguration of British civil air transport came on 25th August 1919, when a daily passenger service was opened between London (Hounslow) and Paris (Le Bourget) by a company called Aircraft Transport and Travel Limited. The year 1919 was also marked by notable pioneer flights including the crossing of the Atlantic by John Alcock and Arthur Whitten Brown in June (both were later knighted for their achievement) and the first flight between England and Australia by Captain (later Sir) Ross Smith and his crew in November and December.

In 1923, a Civil Air Transport Subsidies Committee recommended the merger of the four existing small British companies into one organisation capable of developing overseas routes. In April 1924, the merger took place and there came into being Imperial Airways Limited, which received a Government grant of £1 million spread over the next ten years. As a substantial shareholder the Government was represented on the Board of Directors.

Imperial Airways Limited proceeded to pioneer the commercial development of intercontinental air-routes, following up, in most cases, the exploratory work of the Royal Air Force. Pioneering involved organising ground services upon which civil aviation could rely. The route to the Far East came first. In 1927, a link was established between Cairo and Basra and by 1929 there was a through service from England to India. In 1931, the first service was established to Central Africa. The first mail service between London and Australia was begun in December 1934, followed by a passenger service in 1935.

In 1937, crossings of the Atlantic were made simultaneously by Imperial Airways with the modified 'Empire' class flying-boat and by Pan American Airways. In 1939 a transatlantic service was operated by both companies. The British Overseas Airways Corporation was established by the British Overseas Airways Act, 1939, and took over the undertakings of Imperial Airways Limited and British Airways Limited in 1940.

During the second world war the British Overseas Airways Corporation operated essential overseas air services in support of the war effort. By the end of the war it was carrying more than twice as many passengers as in 1939 and more than three times as much freight. The routes moreover, had efficient radio and radar systems which had been installed for war purposes and were adapted for civilian use; there were also about 700 ærodromes in the United Kingdom, although most of them, having been constructed for war purposes away from large towns, were unsuitably placed for civil use.

The one serious obstacle to a continued expansion of British civil air transport after the war was the absence of any new British civil aircraft to take the place of the pre-war types. The British aircraft industry throughout the war had concentrated entirely on the production of fighters and bombers for the Allied Forces, leaving the production of all transport aircraft to the Americans. Since the evolution of a new airliner takes from five to ten years, there was an awkward gap in the natural development of British civil air services which could be filled only by the use of uneconomical converted military types, or the purchase of foreign aircraft. Both expedients, together with the use of the highly successful interim short-range *Viking* aircraft were, in fact, used while the British aircraft industry concentrated on the development of the turbo-jet and turbo-prop airliners, e. g., *Comets*, *Viscounts* and *Britannias*.

II. THE CORPORATIONS

As already noted, the British Overseas Airways Corporation (BOAC) was set up in 1939. The Civil Aviation Act, 1946, set up two additional public corporations; British European Airways (BEA) to cover the United Kingdom and Europe, and British South American Airways (BSAA) to operate to South America and the Caribbean, leaving the North Atlantic and Eastern Hemisphere routes to BOAC. In 1949 BSAA was merged into BOAC by the Airways Corporations Act of that year. The statutory Provisions (now laid down by the Air Corporations Acts, 1949 to 1956) relating to the powers and constitution of BEA and BOAC are as follows :

Operations. Scheduled services are reserved to the two Corporations, working alone or through associates. They can also engage in charter work. They may not manufacture airframes, aero-engines or propellers.

Constitution. Each Corporation consists of a chairman, deputy chairman, and not fewer than five or more than eleven directors. Appointments are made by the Minister who, in the case of BOAC, may, if he wishes, appoint two deputy chairmen.

Finance. Each Corporation may, with Treasury consent, borrow either by raising temporary loans or by issuing stock. The Treasury may guarantee redemption or repayment of, and payment of interest on, any stock issued and temporary loans raised. By section 42 of the Finance Act, 1956, the Corporations may also, until 31st March 1958, raise money by means of interest-bearing redeemable loans from the Exchequer. Under the Air Corporations Act, 1956, the borrowing powers of BOAC and BEA are limited to £160 million and £60 million respectively. This Act also provides that BOAC may, with the consent of the Treasury, borrow from the International Bank or the Export-Import Bank of Washington in order to buy aircraft manufactured in the United States of America and spare parts and equipment for such aircraft. Provision was made in earlier Acts for Exchequer grants up to a limit of £8 million a year (for both Corporations together) until April 1956, so as to enable the Corporations to build up their organisation and services over a period of years. (For 1946—47 and 1947—48 the maximum was £10 million.) BOAC has operated without Exchequer grant since 1952—53 and BEA since 1955—56. The Corporations are not exempt from liability for any taxes or rates.

Accounts. Statements of accounts in a form approved by the Minister and the Treasury have to be prepared by the Corporations for each financial year. The accounts are audited by auditors appointed annually by the Minister.

Annual Reports. Each Corporation must also make an annual report to the Minister, and the Minister must lay a copy of this report and of the accounts before both Houses of Parliament. In addition, each Corporation must submit before the beginning of every planning period (each three-year period, beginning 1st April 1947) a programme of the services it proposes to provide and of any other activities it proposes to engage in, as well as an estimate of its receipts and expenditure on revenue and capital account during the period.

Labour Relations. Each Corporation must, unless it is satisfied that adequate machinery already exists, consult with any organisation which it considers appropriate with a view to establishing machinery for settling terms and conditions of employment and

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(Continued from page A.6)

the full power of the starter is developed. Moreover, since the amount of fuel available at any one start is only that required for one start, it is much easier to ensure that any form of failure in the starting system is a failure to safe conditions.

The cartridge used is a size already standard in R. A. F. Stores, and it is expected that one size of cartridge will be used for all sizes of engine. The variations in starting requirements between different engines will be accommodated by adjustments to the stroke or size of the fuel injector.

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[1] Up to 1945 civil aviation was administered by the Department of Civil Aviation of the Air Ministry. Between 1945 and 1953 the Ministry of Civil Aviation was the responsible Government Department and, in October 1953, the Ministries of Civil Aviation and of Transport were amalgamated. In the rest of this paper, reference will usually be made only to 'the Minister' or 'the Ministry'.

for discussing matters affecting the safety, health and welfare of its employees and other matters of interest to both parties, including efficiency in operating the Corporation's services. In 1946 the *National Joint Council for Civil Air Transport* was set up as the body through which terms and conditions of service between the Corporations and the 18 Trade Unions representing the employees are negotiated. A number of the independent air transport companies have since become members of the Council.

Ministerial Control. The Corporations conduct their own affairs as commercial businesses. The Minister can give general directions on matters affecting the national interest but in practice this power is rarely, if ever, used, since it has been found much more suitable to proceed by means of close consultation and discussion with the Corporations. In fact, the Minister has maintained closer control over them than has been the case for the other nationalised industries. During the Exchequer grant period (1946—56) the Minister had to decide in consultation with the Treasury what grants, within the ceiling of £8 million, should be given to each Corporation in any particular year. This necessitated a close examination of the Corporations' programmes of air services and financial estimates. The Minister also keeps in close touch with the Corporations regarding plans for new aircraft and new routes since he has to negotiate the necessary rights with foreign governments. He also provides most of the aerodromes from which the Corporations operate and the navigational aids and communications necessary to the conduct of their flights. Contact between the Corporations and the Ministry is, therefore, close, mainly in the form of daily informal exchanges of information between their staffs.

III. INDEPENDENT COMPANIES

The Government considers that non-scheduled or charter services are mainly the domain of the independent companies. The Corporations are not precluded from engaging in this work but they do not maintain aircraft specially for it. The operation of scheduled services by independent companies under associate agreements with the Corporations was introduced in 1948. Applications to operate these services were considered by the Air Transport Advisory Council which recommended to the Minister whether or not approval should be given. In the main, agreements were of short duration, the routes being those which the Corporations did not, at the time, plan to operate, e. g., some internal routes, short-haul ferry services across the English Channel and a few holiday routes to the Continent.

The opportunities for independent companies to take part in air transport developments were increased in 1952. In May of that year the Minister outlined the principles which would be followed in shaping the Government's policy for air transport development. These were, broadly, to combine public and private enterprise in the best interests of British civil aviation; and to promote sound development, reduce the cost to the taxpayer and give greater opportunities to private enterprise without impairing the competitive strength of Britain's international services and without undermining the existing international networks of BOAC and BEA.

This policy is being implemented within the existing legislation so that independent companies seeking to take advantage of new opportunities to operate scheduled services continue to be appointed associates of one of the Corporations. Applications by independent companies continue to be made to the Air Transport Advisory Council but are considered under new terms of reference issued to the Council in July 1952. Under these terms of reference, the Corporation's position is safeguarded by reserving to them the sole right to operate first and tourist class services on their established routes. Independent companies and the Corporations alike, however, are eligible to apply for the right to develop new routes not so reserved and new types of scheduled services: for example, international services which do not serve the same traffic areas as services by BEA or independent companies already approved, services operated solely for the carriage of freight and 'Colonial coach class' services (i. e. services to United Kingdom territories overseas providing a lower standard of service than the tourist class and so generating a new class of traffic).

The Air Transport Advisory Council considers applications in the light of its terms of reference and, after hearing evidence from interested parties, makes recommendations to the Minister. Approval of the operations of scheduled services by independent companies as associates of the Corporations is now normally given for seven years with extension to ten years in special circumstances, for example, where the purchase of new aircraft is involved. In this way, it is intended to give independent companies sufficient long-term security to justify capital outlay and expansion.

IV. OPERATIONS

The latest available information about the services, fleets and results of the two Corporations, and the activities of the independent companies are summarised below.

BRITISH OVERSEAS AIRWAYS CORPORATION

The British Overseas Airways Corporation (BOAC) operates scheduled services to the Middle and Far East and to Australia, with terminals at Sydney, Tokyo, Hong Kong, Singapore, Colombo, Karachi, Bahrein, and Aden; to Africa with terminals at Johannesburg, Nairobi, Accra, Lagos and Dar es Salaam; and to North America and the Caribbean with terminals at New York, Chicago, San Francisco, Montreal, Jamaica and Trinidad. There are regional services between New York and Bermuda, Nassau and Montego Bay; the services between New York and the last two points operate as extensions of the London-New York route. The routes to Central and South Africa are operated in partnership with Central African Airways and South African Airways, and the route to Sydney in partnership with Qantas Empire Airways of Australia. Qantas carries on the service from Australia by operating routes to North America—formerly operated by British Commonwealth Pacific Airlines which went out of existence on 31st March, 1954—which connect at San Francisco with BOAC's San Francisco to London service, and thus provide a Commonwealth round-the-world air service. Tasman Empire Airways, jointly owned by the Australian and New Zealand Governments, operates service between Australia and New Zealand and from New Zealand to Fiji and other islands of the South Pacific.

This network of services is supplemented by the activities of subsidiary and associated enterprises overseas in which BOAC participates financially or with which it has technical or management agreements.

Those in which BOAC has a controlling financial interest include *Aden Airways Ltd.*,[1] operating in the southern Red Sea area; *Bahamas Airways Ltd.*, providing services between the islands of the Bahamas and to Florida (USA); *British West Indian Airways Ltd.*, which provides services throughout the Caribbean area and to New York; and *Gulf Aviation Company Bahrein Ltd.*,[1] which operates in the Persian Gulf area. Companies with which BOAC is associated either financially or through advisory and other agreements include *Middle East Airlines Company*[1] which operates services from the Lebanon throughout the Middle East and to Europe; *West African Airways Corporation* and *East African Airways Corporation*, serving West and East Africa; *Malayan Airways Ltd.*, which operates services in the Federation of Malaya, Singapore, North Borneo, Brunei and Sarawak; *Hong Kong Airways; Cyprus Airways Ltd.; Iraqi Airways; Kuwait Airways;* and *Arab Airways*[1] which provides services for Jordan. BOAC, like BEA, is also associated with *International Aeradio Ltd.*

To implement its policy of extending the benefits of air travel to a wider public by charging lower fares, BOAC has introduced tourist services on many routes and in 1955—56 tourist passengers accounted for 53 per cent of those who travelled on the Corporation's services.

On all its services, BOAC carried, in 1955—56, 385,778 passengers, 7,051 tons of freight and 3,815 tons of mail. The figures in 1947—48 were 115,675 passengers, 2,447 tons of freight and 2,088 tons of mail.

BOAC's fleet in May 1957 consisted of: 10 Mark 102 *Britannias* which came into service on the Johannesburg route on 1st February, 1957, to Australia on 2nd March, 1957 and were due to begin services to the Far East in the summer of 1957; 19 *Argonauts;* 14 *Constellations* (five of which are awaiting disposal); 16 *Stratocruisers;* 10 *DC 7Cs;* and 2 *Yorks.* At that date orders had been placed for the following British aircraft; 5 Mark 102 *Britannias;* 18 Mark 312 *Britannias;* 1 Mark II *Comet;* 19 Mark IV *Comets;* and 12 *Viscount 700 Ds;* it had also been decided to order 35 Vickers *VC 10s.* In addition, orders had been placed in the United States of America for 15 *Boeing* jet aircraft.

Progress is also being made in the development of the larger Mark 312 *Britannia* in both long—and medium—haul versions.

The *Comet I* (with which the world's first scheduled jet service was started on 2nd May, 1952) had been progressively introduced into the Corporation's fleet until April 1954 when, following accidents which involved the loss of two aircraft, it was withdrawn

[1] BOAC's interests in these companies are held by Associated British Airlines (Middle East) Ltd., a company in which the Corporation has a major interest.

from service pending the report of a Court of Inquiry. This report was published in February 1955. The Court found that the cause of the accident to the *Comet* wrecked off Elba in January 1954 was the structural failure of the pressurised cabin brought about by fatigue. The Court thought it possible that the same cause accounted for the loss of another *Comet* near Naples in April 1954. It made a number of recommendations designed to prevent future similar accidents and these were accepted by the Government. BOAC's faith in the future of the *Comet* is demonstrated by the order it has placed with de Havillands, the manufacturers, for the Mark IV *Comets* which will incorporate the improvements in structural design that are the outcome of research and of the findings of the Court of Inquiry. Delivery of these aircraft will begin in 1958.

In the year 1951—52 BOAC for the first time made a net profit of nearly £275,000, after allowing for interest on capital and before crediting the Exchequer grant of £1½ million. In 1952—53, when the profit (before providing for interest on capital) was reduced from £1.2 million to £104,000 mainly owing to an increase in costs—including increased wage rates and costs of materials, spares and fuel—BOAC abstained from claiming any Exchequer grant and the deficit of £839,000 remaining after paying interest on capital was carried forward. In 1953—54 the profit was £2 million, and after paying interest on capital, providing for future income tax and profits tax and allowing for capital and other surpluses, there remained a balance of £936,911 to be applied to the reduction of the accumulated deficiency. In 1954—55, a year made difficult by the withdrawal of the *Comets* from service in April 1954, the profit fell to £1.4 million and, after paying interest, the surplus was £262,000. At the end of March 1955 the Corporation's accumulated deficiency was £862,000, but during 1955—56 BOAC was able to wipe out this deficiency and, at 31st March, 1956, showed for the first time in its history a small accumulated surplus of nearly £18,000.

Over the whole nine-year period up to the end of March 1956, the capacity on BOAC services increased from 89.5 million to 260.3 million ton miles; operating revenue increased from £14.6 million to £42.7 million; operating costs were reduced from 57.7 pence per ton mile to 38.0 pence; and the break-even load factor (the proportion of aircraft space it is necessary to sell in order to cover all costs of operation and administration including interest on capital) fell from 115 per cent to 61 per cent.

BRITISH EUROPEAN AIRWAYS

British European Airways (BEA) is the seventh largest airline in the world judged by the annual number of passengers carried: 2,224,747 in 1955—56, when it operated on its own behalf, in conjunction with its associated companies and subsidiaries, a network of services covering 25,367 unduplicated route miles serving 67 airports in the United Kingdom, Europe and North Africa, within a periphery on which the farthest points to the north, south, west and east are Bergen, Benghazi, Lisbon and Beirut. Its services within the United Kingdom include a number which cannot be operated commercially with the equipment now available but which meet a vital social need. These include services to the Highlands and Islands of Scotland, winter services to the Isle of Man and inter-Channel Islands services. Tourist fares have been introduced on all BEA's domestic routes and on almost all its international routes. BEA maintains a close working relationship with BOAC, whose aircraft of necessity fly through a number of European stopping points on their way east and south. BEA also co-operates with other airlines in order to create 'through travel' facilities. In addition to passengers, BEA carried 18,586 tons of freight and 7,895 tons of mail in the year 1955—56.

A subsidiary of BEA, *Gibraltar Airways Ltd.*, operates services between Gibraltar and Tangier. BEA is associated financially with *Aer Lingus*, working primarily between the Irish Republic and the United Kingdom; *Aerolinee Italiane Internazionali (Alitalia)* which operates services within Europe and also to East Africa, the Middle East and South America; *Cyprus Airways Ltd.*, which operates services to Turkey, Greece, Lebanon, Egypt, Jordan, Israel, North Africa, the Sudan and the Persian Gulf; and *Malta Airways Company Ltd.* BEA is also associated with *Societe Internationale de Telecommunications Aeronautiques* (SITA), a Belgian company which provides communications circuits for subscribing operators; and, like BOAC, with *International Aeradio Ltd.*

BEA's fleet in May 1957 comprised: 25 *Viscount 701s*; 12 *Viscount 802s* 19 *Elizabethans*;[1] 38 *Pionairs*; 8 *Pionair Leopard* Freighters; 4 *Herons*; and 3 *Rapides*. Aircraft on order at that date consisted of 12 *Viscount 802s*; 14 *Viscount 806s*; and 20 *Vanguards*.

[1] BEA expected to have sold all their *Elizabethans* by the end of 1957, as these are being replaced by *Viscounts*. It is BEA's policy to build up an all gas-turbine fleet of airliners, which will eventually total 80 *Viscounts* and *Vanguards*.

The *Viscount V. 701* 'Discovery' class was brought into regularly scheduled service on 16th April, 1953, on the routes to Istanbul and Cyprus, thus inaugurating the world's first commercial operations with propeller-turbine aircraft. During 1955—56, the 28 *Viscounts* carried 617,432 passengers on both European and internal services. A larger version of the *Viscount*, the *Viscount 800*, was brought into service in February 1957 between London and Paris; and in April 1957, it inaugurated BEA's first service to the Republic of Ireland, on the London to Dublin route. Work is already in hand on the production of a new fleet of *Vanguards*, an airliner of 'double-bubble' or 'figure of eight' construction, providing exceptionally capacious freight holds, as well as accommodation for 90 or more passengers. It is hoped that these aircraft, of which BEA has ordered 20, will be delivered in 1959—60.

Since 1950, BEA has operated various scheduled services with helicopters, in order to obtain experience in the civil operation of helicopters which can be used to assist the design and production of a commercial twin-engined British helicopter, and the development of navigational aids and ground facilities. At first, BEA worked with the American type *Sikorsky S.51*, but towards the end of 1951 the first British-built and designed helicopter suitable for scheduled flying, the *Bristol 171*, became available and, after working for a period with one lent by the Ministry of Supply, BEA took delivery of two in June 1953, one of which has since been sold. This, like the *S.51*, is a single-engined helicopter. A prototype twin-engined helicopter, the *Bristol 173*, has been developed on which BEA have gained some flying experience, but the commercial version needed by BEA for the operation of passenger services is not likely to be available for airline service for some years. At the end of 1956, BEA's helicopter fleet consisted of one *Bristol 171*, one *Bell 47B* (used for training purposes) and three Westland *Sikorsky WS. 55s*.

As part of the process of obtaining experience, BEA has operated the following scheduled passenger or freight helicopter services: in 1950—51 from Cardiff to Liverpool; in 1951—54 from Birmingham to London; in 1954—55 from London Airport to Eastleigh (Southampton); from July 1955 to May 1956 from London Air port to a site adjoining the Waterloo Air Terminal; and from July to October 1956 between Nottingham and Leicester and Elmdon (Birmingham).

Over the period 1947—48 to 1955—56, BEA's capacity increased from 22 million to 124 million ton miles, operating revenue from £4 million to £21.6 million, total costs were reduced from 83.6 pence per ton mile to 40.5 pence, and the break-even load factor on total costs fell from 115 per cent to 61.4 per cent. BEA is faced with the problem of securing adequate revenue from short-haul routes aggravated by a marked seasonal variation in its traffic.

In 1954—55 BEA achieved its first net profit of £63,000. In 1955—56 it earned a net profit of £603,614, which was sufficient to wipe out its accumulated deficit and leave a surplus of £64,528.

INDEPENDENT COMPANIES

The scheduled services that the independent companies operate as associates of BOAC or BEA include internal services; passenger services on certain international routes, chiefly from places outside London to Europe, the Channel Islands and the Canary Islands; cross-channel vehicle ferry services; 'Colonial Coach Class' services; inclusive tours (mainly in the holiday season); and various domestic and overseas all-freight services. In 1955—56 some 550,000 passengers were carried by the independent companies on these scheduled services, compared with 253,000 in 1954—55 and 65,000 in 1950—51. The total traffic of these companies on scheduled services increased from just over 1 million ton-miles in 1950—51 to over 23 million ton-miles in 1955—56. But by far the greater part of the independent companies' operations consists of air trooping and general charter work; in 1956 these activities together accounted for 77 per cent of the total capacity ton-miles of the independent operators. The general charter work covers a wide range of business, including transporting the staff of public or private concerns operating overseas; taking seamen to ships in overseas ports; taking parties to football matches and race meetings in the British Isles; carrying livestock, machinery and other valuable or fragile cargo; and bringing perishable foodstuffs and flowers from the continent of Europe to the United Kingdom market. There are also several firms that specialise in non-transport aerial activities notably, aerial survey and pest control.[1]

[1] See C. O. I. Reference Paper, R. 3409 of October 1956. *Some Specialised Uses of Aircraft in the Commonwealth. Non-Transport Activities of United Kingdom Companies and Use of British Aircraft Overseas.*

The independent air transport operators have a total fleet strength of over 250 aircraft. The types include *Yorks, Bristol Freighters, Hermes, Vikings, Dakotas, Viscounts, Supertraders, DC.4s* and *Solent* flying boats. A number of these companies are members of the British Independent Air Transport Association Ltd. The larger of them have subsidiary companies abroad, and in some cases provide the management of small foreign airlines. Much charter business is now arranged through the Air Section of the Baltic Exchange, the London market for shipping space. In this market, business from any part of the world is handled between brokers representing, on the one side, the owners of aircraft available for hire and, on the other, the prospective shippers of cargo or organisers of passenger trips. Inquiries for the charter of aircraft were first received on the Exchange as long ago as 1925, but it was not until 1947 that an Air Section was formed. To assist the market, the Baltic Exchange set up an air freight advisory committee but this was dissolved on 1st February, 1949, when the Airbrokers' Association was formed. Among other aims, the Association seeks to promote and establish uniformity in transactions and usages in the airbroking trade, to establish in London a world market for chartering aircraft to carry cargo and passengers, to represent the interests of its members to Government Departments and other bodies, and to provide commercial arbitration machinery for the assistance of its members.

A recent development has been the increasing participation of shipping finance in independent air companies: e. g., the Clan Line has acquired a 50 per cent non-controlling interest in the Hunting Group, Furness Withy and Blue Star Line have both acquired a substantial interest in Airwork Ltd., the Peninsular and Oriental steam Navigation Company Ltd. (P and O) has acquired a majority shareholding in another independent company, Britavia, and the Bibby Line has acquired a substantial holding in Skyways Ltd.

V. POWERS AND DUTIES OF THE MINISTER

The Civil Aviation Act of 1949, which superseded both the Ministry of Civil Aviation Act, 1945, and the Civil Aviation Act, 1946, gives the Minister the duty of 'organising, carrying out and encouraging measures for the development of civil aviation, for the designing, development and production of civil aircraft, for the promotion of safety and efficiency in the use thereof, and for research into questions relating to air navigation'.

The Minister's duties in regard to the development of civil aviation cover the Minister's relationship to the Corporations (as laid down in the Air Corporations Act of 1949) and his general responsibility for carrying out policy; participation in the International Civil Aviation Organisation; responsibility, in concert with the Foreign Office and Commonwealth Relations Office, for dealing with other countries in civil aviation matters; and the work of the *Air Transport Advisory Council.* This body was established by the 1946 Act primarily to bring to the Minister's notice important representations from the public concerning any inadequacy in the services provided by the Corporations. It was also laid down that its duties should include the study of any question related to the air transport services which the Minister may refer to it. Under this provision, the Minister has given the Council the task of considering and making recommendations to him on applications from independent companies to operate scheduled services as associates of one of the Corporations. This has, in fact, provided most of the Council's work, which has been increased following the Government's decisions in 1952.

The Act requires that the chairman of the Council must be a lawyer and, of its two to four members, at least one must be experienced in the operation of air transport services and one in other forms of transport. The Council makes an annual report to the Minister who lays it before Parliament.

The supervision of design, development and production of civil aircraft has been delegated to the Ministry of Supply, which is also responsible for the provision of all Service aircraft and carries on an extensive programme of research and development to meet civil and Service needs. The Minister of Transport and Civil Aviation is specifically debarred from 'producing' aircraft, and any dealings he may have in aircraft, engines and equipment are subject to Treasury approval.

In exercising his responsibility for safety, the Minister regulates the operation of aircraft and controls the licensing of flight crews. On all safety matters, the Minister may call upon the advice of the *Air Safety Board,* a standing advisory body of experts responsible to him for keeping under continuous review the needs of safety in British civil aviation and for recommending measures calculated to promote safety, in respect of both the operation of British civil aircraft throughout the world and the efficiency of the system of ground facilities provided for all civil

aircraft operating over the United Kingdom.

On airworthiness matters the Minister is advised by the *Air Registration Board,* to which he has delegated certain functions relating to the design, construction and maintenance of civil aircraft. The Board is a non-profit-making incorporated body which was set up in February 1937 and consists of 18 members, of whom 16 represent the interests concerned with civil aviation and two are appointed by the Minister. The Board is responsible, *inter alia,* for the investigation of aircraft for the purpose of making recommendations to the Minister for the issue of Certificates of Airworthiness. Persons engaged in the maintenance of civil aircraft must be the holders of appropriate licences issued by the Board, or must be members of firms approved by the Board for the purpose.

The Minister is authorised (as are local authorities, subject to his approval) to establish and maintain aerodromes for civil aviation. All civil aerodromes not under the Minister's direct control, which are used for commercial operations, are subject to his licensing, inspection and regulation.

The Minister is responsible for determining the conditions, e. g., use of aerodromes and choice of routes, under which aircraft may fly within the United Kingdom and of those under which passengers or cargo may be carried. He is also responsible for various other matters, including the use of signals to and from aircraft, the prevention of interference (e. g., from displays of lights and signs from shops) and the effectiveness of navigational aids. The Minister is jointly responsible with the Minister of Health for sanitary control at his aerodromes, and he also assists the appropriate Department in the application of customs and immigration regulations.

VI. AERODROMES

There are approximately 100 civil aerodromes in the United Kingdom and, in addition, about 50 Service aerodromes are available for civil use. Those under civil control include 26 directly controlled by the Ministry, 3 in the Channel Islands and 1 in the Isle of Man administered by the local governments, and 26 aerodromes licensed for public use, of which 16 are owned by municipalities. Customs facilities are provided at 12 of the Ministry's aerodromes and at 12 others. The Ministry which advises the Colonial Office on civil aviation matters, has also assisted United Kingdom dependencies overseas in equipping and maintaining civil aerodromes and in providing necessary technical facilities to accepted international standards.

The main airports used by international scheduled services in 1956—57 were:

- for European services: London, Renfrew, Birmingham (Elmdon), Manchester (Ringway);
- for North Atlantic services: London, Prestwick, Manchester (Ringway);
- for Middle East, Africa and Far East services: London.

Substantial increases in aircraft and passenger movements at the principal aerodromes have continued from 1945 to 1956. In the latter year, all United Kingdom aerodromes handled nearly 6 million passengers. Of this total, London Airport dealt with 3 million. Outside the London area, Manchester (Ringway) handled the largest number, 387,328 followed by Glasgow (Renfrew) 373,948, Belfast (Nutt's Corner) 270,413, Prestwick 243,307 and Isle of Man (Ronaldsway) 215,709. The number of movements of aircraft engaged on commercial transport operations in 1956 was 293,464 for all United Kingdoma erodromes. The Central Terminal Area at London Airport was opened on 17th April, 1955. On that day the airport was divided into two parts for traffic purposes, 'London Airport North' and 'London Airport Central'. Broadly the long-haul services and Royal Dutch Airlines (KLM) continued to be handled at the North terminal; the bulk of the European short-haul services have been transferred to London Airport Central.

As the main alternate to London Airport, to be used when bad visibility involves diversion and also as a base for seasonal services and charter operators, it has been decided to develop Gatwick, 25 miles south of London, while Blackbushe, west of London, will be used as the supplementary aerodrome to handle aircraft which for any reason cannot use the main alternate. Prestwick is being developed as the second international airport in the United Kingdom.

VII. AIR TRAFFIC CONTROL

The main air traffic control centres are in London for Southern England, Preston for the North, and

Prestwick for Scotland and the Atlantic, while each airport has its own traffic control unit. An airliner flying into Britain is directed by one of the control centres on to a specific route and height in the Control Zone. From this it is passed to the airport control tower. It is brought to within a few miles of the airport by the Approach Controller and then handed over to the Aerodrome Controller for landing and taxi-ing instructions.

Radar plays an important part in air traffic control, monitoring the flight of aircraft and guarding their safe separation from each other, when in flight and when landing or taking off. Even in bad weather a pilot can be brought down to within sight of the runway by means of the radio and radar aids now in use, such as the Ground Controlled Approach system (GCA), operated by a mobile radar unit on the airport, which provides the control officer on the ground with a picture of the aircraft's position in the air, and the Instrument Landing System (ILS), which operates an indicator in the pilot's cockpit to guide him along the correct course and angle of descent required for the approach. Meteorologica information is provided by the Meteorological Offic of the Air Ministry.

VIII. NAVIGATIONAL AIDS

Adequate radio navigational facilities are essentia to enable aircraft to remain safely within controlle airspace and to make accurate estimates of their time of arrival.

The airways are marked by a system of mediun frequency radio ranges, radio beacons and very-high frequency (VHF) fan markers that help the pilot t steer his aircraft along the required route. Durin the next two or three years a number of very-high frequency (VHF) omnidirectional radio ranges will b installed at strategic points in the country. Thi system may eventually replace many of the presen medium frequency ranges and beacons. In addition the coverage provided by the four Decca 'chains' now operating in Britain under the Decca Air an Marine Navigator system, will enable any aircraft fitte

with the appropriate receivers and automatic flight log to follow any of the air patterns at present planned.

A vital part of the technical services provided by the Ministry is a network of radio stations giving communication between ground and air. About fifty of these stations, at aerodromes and other places, provide rapid and efficient communication operating in the VHF band to aircraft in flight over and near the United Kingdom. Special stations at Birdlip (Gloucestershire) and Prestwick (Scotland), operating in the high frequency (HF) band, maintain communication with aircraft on the long-distance routes such as the North Atlantic and South African routes. There is also an extensive system of point-to-point communication between aerodromes and air traffic control centres in the United Kingdom, and to places abroad. Over this system are transmitted such messages as flight plans and weather, so vital to safety and regularity. The main United Kingdom signals centre is at Croydon (near London), where a station, specially designed for the purpose, sends and receives traffic over a network of teleprinter and radio circuits. Its handling capacity is about 30,000 messages a day.

On routes outside the United Kingdom, British airline operators rely upon ground organisation provided by the countries over which they fly. In January 1947, the Airways Corporations (which at that time included BSAA) took the initiative in forming a company, registered in the United Kingdom, called *International Aeradio Limited* (IAL), for the purpose of helping countries in need of assistance in providing radio communications, air traffic control and navigational facilities for civil aviation. Airlines of other countries have accepted invitations to become shareholders, and the membership is broadly representative of international civil aviation. IAL operates by entering into contracts with Governments to provide whatever degree of assistance is required to enable States or Administrations to fulfil the international obligations resting on them under the Chicago Convention on Civil Aviation for the provision and maintenance of ground facilities for civil aviation. In 1957, International Aeradio Ltd. was operating either directly, or through subsidiary or associated companies, in 26 countries. It has over 40 stations all over the world as well as at Yeadon (Yorkshire), Cranfield (Bedfordshire) and London in the United Kingdom. In all overseas areas, IAL trains locally engaged staff up to the standards required for the services it provides; this policy has been so successful that more than 80 per cent of overseas staff are locally recruited.

The *Air-Sea Search and Rescue Service*, operated by the Royal Navy and the Royal Air Force is available to civil air operators within the United Kingdom area and along the overseas routes wherever there are Royal Navy and RAF stations.

IX. INTERNATIONAL AND COMMONWEALTH CO-OPERATION

The United Kingdom actively supports the two principal agencies of international co-operation in the field of civil aviation—the *International Civil Aviation Organisation* (ICAO) and the *International Air Transport Association* (IATA).

The United Kingdom has taken a leading part in drawing up ICAO's standards of air navigation practices and operating conditions and in applying them. It is also a party to the 'joint-support' schemes by which ICAO seeks to ensure the adequacy of air navigation facilities in certain areas. ICAO administers the facilities provided, but their cost if shared between the States whose aircraft use them. Present schemes concern installations in the North Atlantic region, and the United Kingdom contribution includes the maintenance of ocean weather ships to supply meteorological reports, give navigational aid and assist in search and rescue.

IATA is an association of international airlines operating scheduled services for the transport of passengers, mail and cargo. BOAC, BEA and a few United Kingdom independent companies are members. The main functions of IATA are to reach agreement among its members on matters of common interest, to regulate fares and freight rates, to facilitate through bookings, to standardise ticketing, agency agreements, discounts and similar commercial matters. It collaborates with ICAO where necessary.

International exchange of air traffic rights is the subject of agreement between Governments. The United Kingdom Government has negotiated a series of bilateral agreements providing for the reciprocal grant of traffic rights for scheduled services with most of the countries to and through which the United Kingdom airlines operate. So far as charter operations are concerned, the United Kingdom Government requires prior authorisation for all flights on which passengers or freight are picked up or set down by foreign aircraft in the United

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Sperry Integrated Control System

By A Technical Correspondent

IN the expansive years between the two World Wars the civil operation of aircraft could rightly have been classified as an art. So also indeed could military aviation. Since 1945, however, as a result of the great strides made in aircraft design under the stress of war, the art has rapidly been developed into a science. The far higher cost of the modern aircraft with all its complexities demands that it should spend as great as possible a proportion of its life in its revenue earning element, the air. Consequently, those design aspects affecting reliability and ease of maintenance are now assuming an ever increasing importance, linked so closely as they are with economy of operation.

One of the many ways in which the detailed design of aircraft and their equipment has been and is being constantly improved to account for these factors, is exemplified in the new Sperry Integrated Control System which represents a major contribution towards the attainment of the desired goal. The system, known colloquially as the I.C.S., is designed to combine in one comprehensive equipment the facilities of Auto-Pilot, Auto-Stabiliser and Electro-Hydraulic power-operated controls. By comparison with other methods of providing the same facilities separately, involving the complications of separate hydraulic servo systems for the hand-operated power controls and the automatic control functions, a marked simplification has been achieved. By integrating the three services and thus avoiding unnecessary duplication of components, not only has performance, reliability, and ease of maintenance been improved but also an appreciable weight saving has been made.

The principal features of the complete equipment are the actuator units, which may be of the "packaged" type having self-contained electro-

(Continued from page A.17)

Kingdom. Such authorisation may be granted on a reciprocal basis by inter-Governmental agreement or permission may be given for each flight when application is made to the Ministry by a foreign operator.

The progress and development of Commonwealth civil air communications, and provision for the exchange of views and information between Commonwealth countries and for giving advice to them are among the terms of reference of the *Commonwealth Air Transport Council* (CATC). This is a consultative body, without executive powers, which was set up in January 1945, The South Pacific Air Transport Council (SPATC) and the Southern Africa Air Transport Council (SAATC) are subsidiary organisations of CATC. Their terms of reference so far as their areas are concerned are similar to those of CATC in its wider sp ere.

The International Federation of Independent Air Transport (FITAP) is an international association of independent air transport operators which was founded in 1946 and has formal relations with ICAO. Some 20 United Kingdom independent operators that are members of FITAP are also members of the British Independent Air Transport Association (BIATA).

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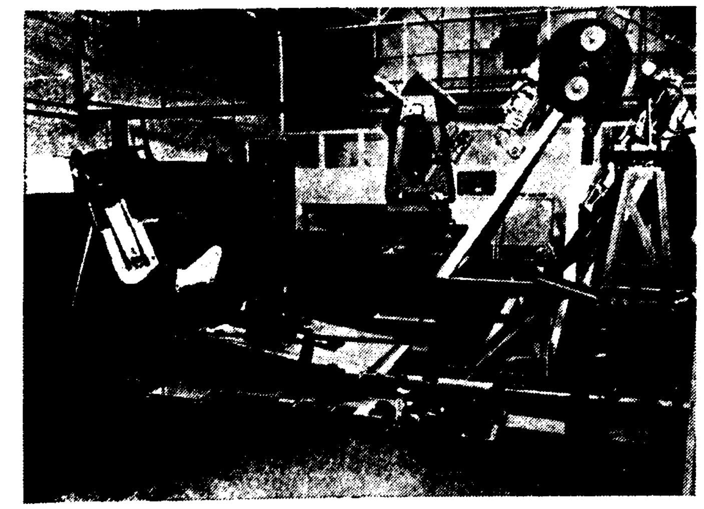


hydraulic power supply, to operate ailerons, elevators and rudder; the autopilot computer; and the gyro reference instruments which supply the attitude and azimuth sensing signals. The standard pilot's controls are used with the system, there being either a mechanical linkage or electrical signalling between the controls and the individual actuator valves. In the latter case, provision is also made for the control surfaces to be operated by direct mechanical linkage for use in the event of emergency.

Four different control modes are available with the system; "Direct" (power operated or mechanical) "Auto-Stabiliser", "Auto-Pilot" and "Rate Control". For the last-mentioned mode, which is generally regarded as a military requirement, a separate miniature stick is used and control movements made by it will automatically result in perfectly co-ordinated flight manoeuvres, the necessary control surface angles being automatically and continuously determined by the auto-pilot computer. In this mode the rudder pedals are used solely to produce side-slip if required, the basic rudder control signals in turns emanating primarily from a lateral accelerometer. The aircraft is flown entirely with the miniature stick and control characteristics are such that even an inherently unstable aircraft can be handled with ease. The primary reason for including a miniature stick is to avoid the possibility of confusion which might arise by having two significantly different control modes on the main control column. It is, however, realised that subject to satisfactory trials the miniature stick could be eliminated and operation in the "Rate Control" mode could be vested in the main control column.

In the "Direct" mode, control surface movements are normally effected through the power-operated actuators but the mechanical reversion can be selected by the pilot if desired. Under certain circumstances, such as in the event of electrical failure, reversion to the direct mechanical linkage between the pilot's controls and the control surfaces is automatic. If, for training or test purposes, the aircraft has been flown with direct mechanical control and it is then desired to re-engage the power-operated actuators, provision is made for this to be accomplished without "kick" in the controls since the automatic pilot system maintains synchronism between the actuators and the imput linkages at all times.

Auto-stabilisation can be engaged at will and is achieved through the auto-pilot computer. Auto-stabiliser movements are limited in amplitude for reasons of safety and do not react at the pilot's input. When in the "Auto-pilot" control mode, control surface movements demanded by the auto-pilot computer produce corresponding movements at the pilot's input. The pilot can at any time over-power the automatic pilot by manual control movement and should he take this action the system automatically reverts to manual powered control. Facilities available in the "Auto-pilot" mode include heading selection, height lock, flight director coupling, I. L. S. coupling and coupling to Weapons Systems. When "Auto-pilot" is selected, the aircraft will maintain the flight path it was following at the instant of engagement until a change is introduced by the pilot with the trimming knobs on the instrument panel.

The basic information for the automatic pilot is obtained from the sensing elements in the aircraft's instrumentation system. This is normally duplicated and thus not only can the necessary safety features be incorporated in the auto-pilot's functional characteristics with no unnecessary duplication of components, but also the system provides an intrinsic integration with the pilot's flight instruments. The auto-pilot computer itself is of advanced design incorporating the use of transistors, printed circuits and other advanced wiring techniques so that electrical contacts have been reduced to a minimum and thermionic valves dispensed with entirely.

New techniques also figure prominently in the design of the hydraulic components in the system. One good example is the "packaged" type of actuator unit which is completely self-contained with its individual electro-hydraulic power supply. Within each unit, all oil connections are via passageways drilled in the casting; thus there are no flexible pipes or swivelling hydraulic joints to leak or cause fire hazard. By the use of variable delivery pumps and by careful attention to valve design, the power consumption is kept to a minimum. The stringent safety requirements have been met by full duplication of power supplies and hydraulic valves, to cater for the emergency case, in addition to the mechanical reversion.

The introduction of this new system represents a significant advance in aircraft control system design philosophy. It can be adapted to meet the requirements of both military and civil aircraft and current design studies include the investigation of its suitability for application to large helicopters.

To develop the project a separate department including specialists in aerodynamic, electronic and hydraulic techniques was created and a simulator designed and constructed by the Company. This includes an electronic analogue computer built into the cabinets seen on the left-hand side of the test room in the photograph. It is referred to as the aerodynamic computer and should not be confused with the aircraft auto-pilot computer which is the nerve centre of the control system itself and is, of course, carried in the aircraft. The aerodynamic computer is of the D. C. type and its function is to compute the motion of the simulated aircraft continuously, given the varying control surface angles and wind gusts.

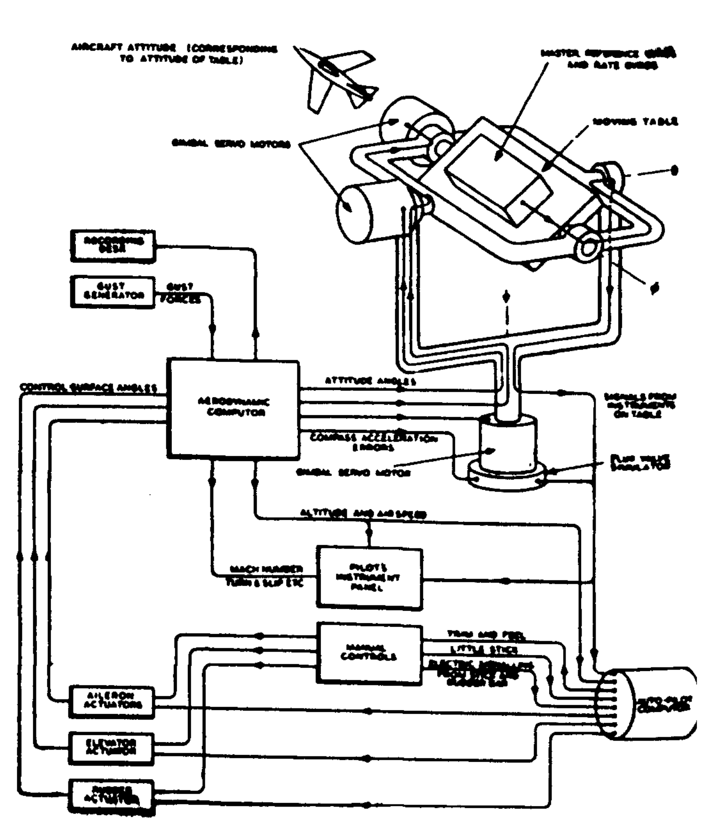
The characteristic feature of the simulator is a gimbal-mounted moving table, the motion of which is controlled by three hydraulic servomotors. This table corresponds to the actual aircraft and on it are mounted the gyroscopes and other instruments for sensing the simulated aircraft's attitude in space. Its output signals are all electrical and are taken through slip rings to the aerodynamic computer and also to a simulated blind flying panel.

The pilot's controls are coupled to the auto-pilot computer in the same way as in an aircraft and the hydraulic actuator units drive loads which are adjusted to have the same aeroelastic properties as the actual control surfaces would have on the real aircraft. The loads are simulated by means of springs and flexibly mounted weights. The large fly-wheel seen in upper right hand corner of the photograph represents the rudder of a twin-jet fighter. To each dummy control surface there is coupled a potentiometer from which voltages, proportional to the control surface angles, are derived. These, together with signals from a gust generator to represent wind fluctuations due to turbulence, are fed into the input of the aerodynamic computer.

The aerodynamic derivatives of the aircraft to be simulated are also set in to the aerodynamic computer by means of knobs on the panels of the equipment.

The main output signals from the aerodynamic computer are three voltages corresponding to the roll, pitch and azimuth angles of the aircraft and these are fed into the gimbal table servomotors in such a way that the table takes up the correct attitude at all times. Other outputs of the aerodynamic computer are height and airspeed which are used to drive small servomotors geared to instruments on the simulated instrument panel and to the barometric capsules in the auto-pilot computer. Further signals are Mach number and Turn and Slip signals for the instrument panel.

It will be seen that the whole simulator is one closed loop system (as shown in the accompanying diagram) consisting of Aerodynamic Computer—Gyro Table (the aircraft)—Gyros—Pilots Instruments



(Continued on page A.21)

INDIA'S AVIATION INDUSTRY or the story of HINDUSTAN AIRCRAFT (PRIVATE) LTD., BANGALORE

INTRODUCTION

THE Second World War gave a great impetus to the advance of technology. And it may be stated, with some authority, that a large share of man's technical effort since, has been devoted more to aviation than to any other single branch of human endeavour. This has been generally true of the industrially advanced west, and in a lesser degree, of an underdeveloped country like India. In common with the rest of world, India seized the opportunity provided by the war. To sustain the war effort and to meet the demands of internal economy, India was compelled to make the maximum use of her internal resources, indigenous skill and enterprise. It was at once an opportunity and a challenge to our industrialists, and they were not slow to respond to the call. Among them was that great industrialist, Seth Walchand Hirachand, who had the foresight and acumen to visualise India as a centre of aviation industry and to lay its foundation. To Bangalore was given the distinction of being the home of the first Aircraft Industry in the East and Hindustan Aircraft Ltd., was established by him on the 24th December 1940 in collaboration with the Government of Mysore. Mr. W. D. Pawley of the Inter Continent Corporation, the well-known American leader in Aircraft Industry, was entrusted with the construction of the plant in Bangalore, and thereby an era of Indo-American co-operation was inaugurated.

HISTORY

Part 1—1940—46.

Shortly after the establishment of the factory, the Government of India became a member of the Company, and a year later the factory was taken over by them completely, so far as the private holdings were concerned. The only two present members are the Government of India and the Government of Mysore. The authorised capital of the Company is Rs. 18 crores. Of the paid up capital of about Rs. 6 crores, the major portion is held by the Government of India.

The original programme of the factory was the manufacture of Curtiss Hawk Fighters, Vultee Bombers, Harlow Trainers and Allied equipment.

Barely eight months after the inception of the factory, the first aircraft was assembled and flown. And an year later, the first Curtiss Hawk P—36, a single seater fighter monoplane was completed and test flown. Almost at the same time, the first ten-seater Glider, locally designed, was built and test flown, marking a land-mark in Indian aviation. Meanwhile more planes, Hawk P—36 and Harlow PC—5, started coming off the production line. Orders continued to pour in. The U. S. Army Air Force Placed an indent for the mass production of Belly Fuel Tanks for the combat aircraft operating with the allied Air Forces. The factory began to expand with the addition of new equipment, machinery and more men to cope with the increasing programme of work. With this expansion, the factory became the Major Maintenance Base for the Far East with the designation, 84th Air Depot of the United States Army Air Force, for the overhaul of Heavy and Light Bombers, Fighters and Catalina Flying Boats etc.

(Continued from page A.20)

—Manual Controls (or alternatively Auto-pilot)—Hydraulic Actuators—Control Surfaces and thence back to the Aerodynamic Computer. It is, therefore, capable of exhibiting all the qualities or faults of the real aircraft and control system combination and can be made stable or unstable at will by appropriate changes.

By a simple process of resetting the knobs, the whole simulator can be changed at once from, for example, the sensitive and rapid response of a high-speed fighter to the ponderous motion of a heavy transport aircraft. Thus the control system can be "flown" in the test room in any aircraft for which the flying characteristics are known and under conditions corresponding to any height or speed desired. A schedule of evaluation trials has been carried out in this way and from the results obtained it is apparent that the use of the simulator for test purposes will have been effective in reducing considerably the normal flight development period for such a system.

In 1943 with the war in South East Asia in full swing, the U. S. Army Air Force, faced with colossal aircraft repair and overhaul requirements took over the Management of HAL from the Government for the duration of the war. All aircraft manufacturing programmes were suspended and the factory began to work round the clock in three shifts. The man power strength of the factory reached the figure of 15,000. A separate engine and overhaul department was formed with the target, in due course, to overhaul 300 Aero Engines a month.

As the war against Japan intensified in 1944, HAL's contribution and importance became enormous and its work elicited the appreciation of the Commander-in-Chief, Allied Air Forces, South East Asia.

With the termination of the war in 1945, the management of HAL reverted to the Government of India. Some idea of the immense contribution made by HAL to the war effort can be gained by the following overhaul figures during the Management of the Factory by the American Army :—

1.	C—47	Cargo Planes	406.
2.	B—25	Light Bombers	374.
3.	B—24	Heavy Bombers	176.
4.		Catalinas	55.
5.		Miscellaneous Aircraft	160.
6.		Aircraft Engines	3,800.

With the end of the war and the consequent curtailment of its activities there was heavy retrenchment in personnel and the future of HAL itself was uncertain.

However, this uncertainty was dissipated by the recommendations of the Aircraft Technical Mission from the U. K. which visited India at the initiative of the Government of India in 1946. In the context of the already existing equipment and facilities, the Mission had no hesitation in recommending that HAL should become the nucleus for the development of aircraft manufacture in India.

Part 2—1946—1953.

With its future decided, HAL began to forge ahead. The first step taken was the formation of a Sales Department and HAL started operations as a commercial undertaking. To start with, an order from the Indian Air Force was received for the repair and erection of 100 Tiger Moth aircraft.

The following year, the year of India's Independence, HAL was recognized at the authorised Douglas Service Centre in India. More orders were received from the I. A. F., this time, for the overhaul of Dakotas and later for the manufacture of Percival Prentice Trainer Aircraft.

At the same time a full fledged Engineering and Design Department was formed at HAL with the appointment of Dr. Ghatage as Chief Designer, who set about organising the Department in right earnest.

The following year (1948) constituted anothei landmark in the development of the factory when i took in hand the designing of its own Trainer aircraft, designated H. T.—2. And the following year, th first Indian built Percival Prentice was test flowi while H. T.—2 wooden mock-up was completed. I the same year HAL, in addition to installing pressurised cabin in a Dakota for the use of th Deputy Prime Minister, the late Sardar Vallabha Patel, converted two I. A. F. Dakotas as Flyin Navigational Class Rooms. Another item of worl undertaken by HAL for the I. A. F. was the modifica tion of a Dakota as a Target Towing Aircraft fo gunnery practice.

In 1950, HAL was admitted as a Member of th Society of British Aircraft Constructors. This yea marked another stage in its expansion with the inau guration of the Apprentice Training Scheme to cate to the increasing requirements of technical an skilled labour to man the different sections in th factory. At the same time HAL placed its faciliti at the disposal of the I. A. F. for short term trainin of their technicians.

1951 marked another notable step forward in th development of the industry with the building an erection of Jet Fighter Aircraft entrusted to it by th I. A. F.,—A technical Liaison Staff from De Havi lands was posted at HAL to co-ordinate its j aircraft production. The first jet aircraft wa assembled and test flown in March of that year b Capt. Munshi. The first HT-2 prototype made i first public demonstration in August. At the sam time the mock-up of an advanced trainer aircraft wa also undertaken; while the Prentice programm entered a new stage—being built from HAL manufac tured jigs and tools.

On the side of training, a 'Training withi Industry' scheme, under the auspices of th

International Labour Organization was introduced at the upper level of Management with the intention ultimately to extend it to all supervisory personnel. Also Engineering Designers and technicians were deputed to the U. K. to familiarise themselves with the latest production methods in use in U. K. factories.

In 1952 the second prototype of the HT—2 was test flown. More and more special conversion of Dakotas for the I. A. F. were undertaken while Aerial Survey Camera modifications were carried out in one Liberator and three Dakota aircraft.

Part 3—1953 and onwards.

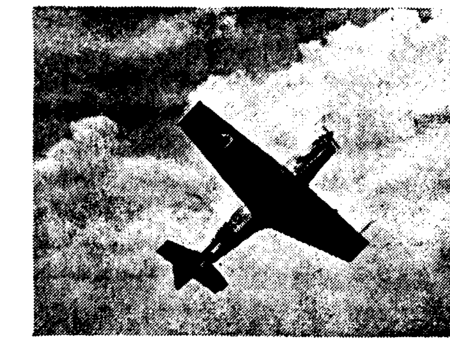
1953 may rightly be described as the year of the H. T.—2. The First Type Certificate in India was presented to H. T.—2 by the Director General of Civil Aviation. Six H. T.—2s flew past before the President of India in New Delhi on 26th January 1953, India's Republic Day. An HT—2 went overseas for the first time to participate in the Ceylon Air Rally in August that year.

The year also marked the completion of the manufacture and delivery of Percival Prentice Aircraft to the I. A. F. The first amphibian aircraft was received from the Navy for repair, while ten Dakotas were overhauled and converted in record time to enable the commencement of the air lift of Haj piligrims by Indamer Company, Bombay.

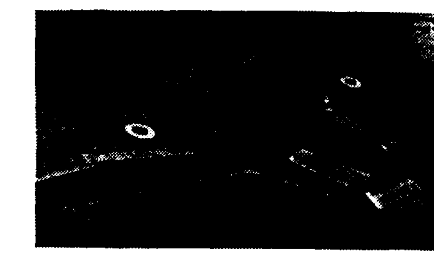
Also the first *Jet fighter manufactured by HAL* was successfully test flown and delivered to the I. A. F. HAL now was awarded the Service Station Certificate for American aircraft by the U. S. Civil Aeronautics Administration and thereby became the first organisation in Asia to achieve this distinction.

During the period 1955—57 HAL turned its attention overseas with a view to exploring market possibilities for its Trainer aircraft, the HT—2 which had entered the stage of commercial production.

In November 1955 an HT—2 from Bangalore covered the countries of Burma, Thailand, Cambodia, Singapore and Malaya on a demonstration tour, flying 4,000 miles in 54.8 hours which included 16 hours for demonstration. Wherever it went, the HT—2 created a big impression and HAL is hoping to market in due course, the HT—2 in this far flung territory. Already Singapore is using an HT—2 for its training programme with an Indian Instructor,



H.T.-2 in flight.



An H.T. on the ground.

under the Colombo Plan. Australia too has evinced interest in this aircraft and an HT—2 is now visiting Australia and New Zealand on a demonstration tour.

Last year (1957) Licence negotiations were completed with Folland Aircraft Company for the manufacture by HAL of Britain's latest Light Jet Fighter, the 'Gnat'. Arrangements were also finalised in collaboration with the Bristol Aero Engine Company for the manufacture of Jet Engines, the first of which will be the 'Orpheus'. A team of British experts arrived in Bangalore and a few HAL engineers were deputed to England to familiarise themselves with the production aspects of the Gnat and the Orpheus. Thus on the foundation stone that was laid 17 years ago, now stands a huge edifice which is bound, as years advance, to add to itself new wings and new columns. To-day HAL has come of age and stands poised at the threshold of a new era in its history—jets and who knows missiles too !

BRANCHES OF THE FACTORY AND THEIR FUNCTIONS

Some idea of the pace of development and the growing sphere of its activities can be gained from the foregoing historical narrative of the factory. It would be seen that her manufacturing projects have tended to grow and her repair and overhaul activities have also been increasing pari passu. Apart from serving as the main overhaul base for internal, Service and Civil aircraft, HAL has all along been also the pivotal point in the East for the repair and overhaul of aircraft from our overseas customers like Ethiopia, Saudi Arabia, Afghanistan, Iran, Ceylon, Burma, Indo-China etc. This branch of her activity is tending to grow rather than diminish.

In order therefore to cope with the mounting demands upon its services, HAL, even as early as 1952, had to initiate a new organisation to lessen its work-load at Bangalore. In that year, a branch of the factory was set up at Barrackpore, near Calcutta, as the first measure of the eventual bifurcation of the two activities—Manufacture and Overhaul. The choice of Barrackpore was influenced by its proximity to our neighbours in South East Asia. This branch has been functioning mainly as an overhaul base for civillian, internal as well as overseas, and Service Aircraft. For the convenience of overseas operators there is an arrangement whereby overhauled engines can be despatched in advance of receipt of repairable units. The work at Barrackpore has been steadily growing and the time is not far off when the entire work of overhaul will be shifted to Barrackpore.

It may be mentioned in passing that two administrative branches of HAL are functioning, one at Calcutta and the other at Madras, whose main job is customs clearance.

This apart, in view of its close connection with the IAF on the manufacturing and overhauling sides, HAL has been maintaining, since 1948, its own technicians for the servicing and maintenance of service aircraft at the following IAF bases—Poona, Jodhpur, Agra, Barrackpore, Jorhat, Begumpet and Cochin (Naval air Wing).

To forecast that as the industry continues to expand itself its functions will become so variegated as to entail the widest possible dispersal of its activities, is no idle prophesy. In fact a position has been reached in the aircraft industry elsewhere in the world where aircraft factories are fast becoming exclusive units of assembly alone. The practice is to allot to subcontractors the manufacture of major components including even sheet-metals together with specifications. It is not uncommon in the West today to see that an aircraft manufacturer is not much more than a "technical library" holding patent rights over his designed aircraft, almost the entire work of manufacture being distributed among specialised units. Until such time as these ancillary industries are established in India which can undertake the production of the various components, specialised and proprietary, HAL has perforce to continue as a comprehensive self-contained unit that it is today. But such a diversification has, however, to come about sooner or later.

WORKSHOP SERVICES

Apart from being unique in itself as the only one of its kind anywhere in the East, HAL is also unique in that, unlike anywhere else in the West, it is a comprehensively self-contained unit, performing within its precincts, the functions of repair, overhaul and manufacture. As it has developed, it has equipped itself with all the ancillary workshops necessary, with the most up-to-date facilities and with skilled and highly experienced technicians in charge, for the repair, overhaul, erection and manufacture of aircraft, aero engines etc. Except for a small number of proprietary parts which have either to be purchased locally or imported from abroad, every repair or overhaul or manufacturing project, be it major or minor, is completed within the factory itself by its own workers and technicians with the available tools and raw materials.

A view of the Aero engine overhaul shop.

Our manufacturing processes (manufacture of aero engines excluded) cover a considerable field and a wide range. Most of our airframe parts are manufactured from imported sheets of Duralumin (U.K.) or Alclad (US) as well as from supplies locally available. We make our own light alloy castings at our foundry for airframes. From imported plastic sheets we manufacture our own canopies. Landing legs (Oleos) for our trainer aircraft are also made by us. Also we make our own tools and jigs. Jig making is a special art and by making our own tools and jigs we have obviated reliance on imports of such items.

Manufacture is carried out to meet international standards and specifications, and inspection is thorough and rigorous. The Chief Inspector responsible for the final check is an autonomous official responsible only to the General Manager.

There are different shops performing different functions. To list a few, they are, the Machine Shop, Finishing, Wood, Rubber, Plastics, Tool rooms, Radio and Radar and Accessories and Foundry. The Machine shop is in a position to manufacture practically the major portion of components for the repairs of planes, engines etc. The Finishing shop gives the final touches like chromium plating, painting, electroplating, etc. In the Wood Workshop, complicated wood work required for Vampires and other aircraft is done. The same is the case in regard to Plastics, and as mentioned earlier HAL is probably one of the few factories in the World which manufacture their own plastic items as well as batteries for their own aircraft.

Special mention of the foundry at HAL is called for. In the last few years there has been developed an up-to-date foundry which has been producing all kinds of ferrous and non-ferrous castings for aircraft like Vampire, HT-2 etc., and rail coaches. Not only the castings but also the patterns are made at the foundry. The requisite alloys both of aluminium and magnesium are entirely produced at the foundry. One of the outstanding developments in the foundry of immense potentiality and value is the introduction of the light alloy forgings for which the machinery is now being installed. Expected to be the foremost plant of its kind in this country its contribution to the aircraft industry is bound to be far-reaching. The foundry is making ferrous as well as non-ferrous castings for the production requirements of Hindustan Machine Tools, Bharat Electronics, etc., sister concerns owned by the Government of India. In fact the foundry's contribution to these two concerns is shortly to be stepped up from the present supply of 50,000 lbs. of castings to 80,000 lbs.

The Engine Overhaul section carries out the complete servicing of engines of the Propeller type while the Overhaul and Vampire sections undertake all the various tasks ending with final assembly.

MAINTENANCE SERVICES

In fact no visitor to the factory would fail to be struck by the manifold services rendered by the different workshops and the way they are run by the maintenance services in the factory. Installation, renovation and general day-to-day maintenance of a variety of machinery, mechanical, pneumatic or electrical, as well as checking up for snags and defects and rectifying them are the main functions of these services. These services are helped by the HAL Foundry, the machine, finishing and other shops in getting components made.

On the electrical side, in addition to wiring and installation of electrical services, repairs requiring skill of a very high order such as winding of motors, repairing and servicing of meters are done by the maintenance services. At the same time all the mobile equipment such as cranes, fork lights, mobile generators etc., are completely serviced by the maintenance department.

The transportation section similarly is self-sufficient for all repairs and overhaul.

Before we close this section, it would be of interest to the reader if we state that the current prices of our services compare very favourably with, and are in fact, much cheaper than similar charges abroad. The same is also true of our Trainer aircraft the HT-2 and the Vampire which are far cheaper than the prices of their overseas counterparts.

When it is considered that the engines as well as a few specialised components have to be imported the attractiveness of the Indian prices will be immediately obvious.

FACTORY ADMINISTRATION - SOME ASPECTS

A narrative like this would be incomplete without a brief mention of what part the latest concepts in factory administration play in HAL. It may be pointed out that in the Post Independence era there has been new thinking in India on the question of a re-orientation of the methods of business administration in the context of the rapid industrialisation of what had been, up to now, a predominently agricultural economy. A lead in this sphere has been given by HAL whose management have contributed, in a large measure, to the setting up of the Institute of Industrial Management which is a country-wide organisation in India, and is a forum for the exchange of views and information on how best to run an industrial undertaking.

Another innovation made by HAL in keeping with modern trends is the *mechanisation of its accounting procedure.* In democratic countries where the nationalisation of important industrial concerns is coming to be accepted more and more as a basic principle of policy the question of running them on sound commercial and economic lines has become imperative. It has therefore become very necessary to pre-determine the costs of such undertakings and to ensure that such costs are carefully checked and controlled when they go into production. HAL has in operation a sufficiently comprehensive costing and cost-controlling system aided by the latest automatic machines.

TRAINING

As referred to earlier in this article, the Apprentice Training scheme which was inaugurated eight years ago is forging ahead. Particularly in an industry like that of HAL, it has been found advantageous to train its own technicians under various apprentice schemes which are pre-planned and which also include training in various other technical institutions in the country.

The training programme is being stepped up further with the opening very shortly at HAL of a Training School and Hostel for the accommodation of the trainees. The new programme has been so designed as to ensure that there is a steady supply of well trained technicians to meet the needs of future expansion and to make available the right type of technicians who are to be recruited every year.

Also in vogue for about seven years now, the "Training within Industry" programme is also making steady progress. Introduced first under the auspices of the International Labour Organisation, it originally covered the upper level of management percolating gradually thereafter down to the supervisory personnel.

Lastly a word about *welfare amenities*. In common with other modern industrial organisations, these amenities at HAL too, cover housing (not all inclusive as yet) schools, recreation facilities, medical attention, markets etc., etc. But one distinctive feature of the welfare services at HAL which is not found anywhere else is the provision of what is described as the 'Death Relief Fund'. Any employee who dies while in service, as a result of his membership of the fund, is entitled to the benefit of a cash grant of Rs. 1,000/- to his family immediately on his death to help them perform the obscquies etc. This is a boon especially in the case of indigent workers and their destitute families.

HAL'S OUTSTANDING CONTRIBUTION— THE HT-2.

While as a result of historical circumstances, HAL's main contribution has lain in the field of Defence, its chief claim to recognition in the sphere of aircraft production is based on its HT—2, a modern, basic, all-metal trainer aircraft which has made a name for itself among its training compeers elsewhere in the world. HAL, had of course, previously manufactured, under license, the Percival Prentice Trainer, but as already mentioned the HT—2 was the first trainer aircraft designed and developed entirely in India by HAL under the able and eminent direction of Dr. Ghatage. This aircraft is now in service not only with the Indian Air Force and the Indian Naval Air Arm but also with the Civil Aviation Establishments in India as well as Flying Clubs. The Civil Aviation Training Centre at Allahabad, has already purchased 9 HT—2s and is expected to order for more; while the Indian Navy have already acquired initially three HT—2s for their training programme. Lately the Hyderabad Flying Club has acquired an HT—2 for its training programme, the first Flying Club in India to do so. As already pointed out, an HT—2 is now in service with Singapore, under the auspices of the Colombo Plan. Sturdy in construction and aerobatic without restrictions, the HT—2 has proved, in practice, to be one of the best aircraft of its class from the point of view of easy and economical maintenance and operation.

HAL'S CONTRIBUTION TO THE DEVELOPMENT OF CIVIL AVIATION

In yet another sphere, HAL has played a notable role—the development of Civil Aviation in INDIA owes not a little to the considerable assistance given to it by HAL. In fact, it is not too much to claim that Civil Aviation in India owed its early growth largely, if not entirely, to the part played by HAL in providing it with a nucleus of aircraft, overhauled and suitably converted for internal civil air transport.

It will be recalled that with the termination of the war, army Dakotas rendered surplus were acquired by the newly formed internal Civil Airlines in India and all these aircraft which had been in different stages of repair, were completely overhauled and converted into passenger airliners. Every aspect of Dakota conversion was handled by HAL including even the manufacture of seats and fittings as well as the overhaul of engines, propellers, radio instruments etc. The rapid development of Civil aviation in India has thus been largely due to the work that HAL has been able to accomplish.

Although strictly speaking no new aircraft were *manufactured* by HAL in the field of Civil Aviation, (apart, of course, from the HT—2 for training purposes) the work of conversions and/or overhaul of

both planes and engines carried out by HAL, to enable such aircraft to obtain certificates of airworthiness, have been an equally vital or greater contribution to the development of Civil Aviation in India. In addition, special Deluxe conversions of aircraft formerly owned by many Maharajas were carried out by HAL and most of these are now in service with a few private operators in India.

Some idea of the general work of overhaul and conversion during the last 12 years by HAL can be gained from the statistical details given below. The types of Civilian aircraft handled by HAL have been as follows:—

1. Dakota,
2. HT—2,
3. Stinson,
4. Aeronca,
5. Bonanza,
6. Lockheed Hudson,
7. Dove,
8. Beechcraft,
9. Tiger Moth,
10. Chipmunk,
11. Aero 45,
12. Harlow,
13. Noordyne,
14. Grumman Goose,
15. Fairchild Argus.

Of these types it may be stated that Dakotas have accounted for the largest number of overhaul/conversions, say 90% and over, followed way below by Tiger Moths. All the other types of aircraft, put together, did not account for more than an infinitely small percentage.

ENGINE OVERHAUL FOR CIVIL USE

The following types of engines have also been overhauled at HAL for Civil use in the period 1946—58:

1. Pratt & Whitney R. 1830—92
   14 Cylinder Radial Engine,
2. D. H. Gipsy Major,
3. D. H. Gipsy Queen,
4. R. 985
5. Cirrus Major and
6. Continental.

Just as Dakotas have formed the largest single type of planes overhauled by HAL, so also the largest single type of engines overhauled has been the Pratt & Whitney R. 1830—92 which power the Dakotas. Out of a grand total of 2493 of all types of engines overhauled at HAL, the R. 1830—92 alone accounted for 2519; Gipsy Queen 302 engines have accounted for 36 and Gipsy Major 30; and Gipsy Queen 70, six.

CONVERSION FOR CIVIL USE

In the last 12 years, (1946—58) the total number of conversions carried out by HAL has been quite considerable—62 for internal operators and 17 for foreign customers. As already mentioned, leaving a few other types, the largest number of conversions has been carried out on Dakotas including De-luxe conversions for VIP's.

To restate the position in a nutshell—during the years 1946—58, a total quantity of aircraft of all types overhauled etc. has been 429; conversions 79 (both internal and external) and engines of all types overhauled, 2593.

Detailed figures are as under:—

Statistical table of Major overhaul work carried out by HAL between 1946 & 58.

(1) MAJOR OVERHAUL WORK OF DAKOTA AIRCRAFT AT H. A. L.

Period	Over-hauled.	Re. C. of A.	Check Inspection	Trainer Aircraft Tiger Moth.	Trainer Aircraft HT-2.
1946–47	41	—	—	—	—
47–48	38	29	—	2	—
48–49	14	38	—	13	—
49–50	3	38	—	7	—
50–51	7	37	—	8	—
51–52	1	28	—	—	—
52–53	—	12	—	—	—
53–54	10	11	—	—	—
54–55	—	17	1	—	—
55–56	—	15	5	—	—
56–57	—	13	15	—	—
57–58(9)	—	8	6	—	—
	114	246	27	30	12 **

** The 12 H. T.–2 represent the number of such aircraft built and delivered for Civil use.

(2) ENGINES (CIVIL) OVERHAULED AT HAL

Period	P & W.R. 1830–92	DH Gipsy Major	D.H. G.Q. 70	R. 985	G.Q. 302
1946–47	142	—	—	—	—
47–48	237	—	—	—	—
48–49	260	—	—	—	—
49–50	249	6	—	—	—
50–51	336	8	—	—	—
51–52	392	12	4	—	—
52–53	158	3	2	—	—
53–54	179	—	—	—	—
54–55	163	1	—	—	—
55–56	111	—	—	—	—
56–57	204	—	—	—	21
57–58(9)	88	—	—	2	15
	2519	30	6	2	36

(3) NO. OF CONVERSIONS CARRIED OUT BY HAL FOR CIVIL USE

Internal 52 (1946–1958) Foreign . 17.

RESEARCH AND DEVELOPMENT

The root of all technological growth is Research which is the very-life-blood of industry. And especially, no aircraft industry can survive which does not pay special attention to research and development. Although the aircraft of to-day is a highly variegated and inevitably complicated mechanism, the main stages of its production are fundamentally three: Design, Development and Testing. Keeping this objective very much in the forefront as has already been mentioned, HAL had, as early as 1947, set up a full fledged Engineering and Design Department with Dr. Ghatage as Chief Designer. The Design and Development wing has on its staff a seasoned hand of highly qualified engineers and experts many of whom have had the benefit of training in foreign countries and whose efforts have already contributed not a little to the rapid development in the field of designing. As one example, the HT—2 has been the product of continuous research and development over the past several years.

Recently, placing an even greater emphasis on the importance of designing, HAL has engaged a team of aeronautical experts from abroad under the leadership of an eminent German aircraft designer, Dr. Kurt Tank, as part of its plans for the strengthening and expansion of the design and development organisation in the Factory.

On the side of research, HAL has the advantage of being able to work in close collaboration with the Aeronautical Engineering Department of the Indian Institute of Science which is also located at Bangalore. This has enabled constant interchange of ideas and data between the two organisations to their mutual advantage, particularly in regard to research and development in the field of Aerodynamics and Airplane Structure. For instance, there has been close collaboration between the two organisations in carrying out the wind tunnel tests on the design of HAL's model, HT—2. The provision of another large tunnel, spinning and high speed tunnels and a structures Laboratory at the Institute of Science are bound to be of even greater benefit to HAL.

HAL is also collaborating similarly with several other important development and research institutions all over the country.

In this context, it would be useful to make a special reference to the notable contribution made by the Foundry at HAL to aircraft production. For example mention should be made of the introduction of the DTD 300—11% Mg-Aluminium Alloy casting for the first time at HAL. The production of this Alloy and the casting technique required in order to obtain castings of class one category, have been quite a problem even for those who have been concerned in the production of such castings, over a considerable period. Even to-day a good deal of research and experimentation is being extensively carried out in the U. K. and other foreign countries in this regard. But, in spite of all its limitations, the HAL foundry has been successful in producing this alloy as well as castings in this Alloy. The Foundry also has produced not only Vampire castings but also the patterns required for the production of Vampire castings besides the patterns and castings for HT—2 and other miscellaneous aircraft.

HAL has in addition its own fully equipped Test Laboratory. It controls the entire sphere of activity—from purchase to production. Testing of raw materials to purchase specifications, control of the processes employed for the manufacture and testing of the final product to service standard—all these comprise the day to day functions of the Laboratory. The Laboratory is also useful in finding out ways and means to anticipate and prevent operational troubles, to improve the manufacturing processes and techniques and to develop new uses for existing materials, products and services.

In this way the Laboratory analyses all processes and lays down specifications, while standards are set for all techniques. It works in co-ordination with the Manufacturing shops.

Work for the Laboratory flows in from almost all departments of the factory. The Finishing and Quality Control Departments call for process checks, while metallographic and X-ray examination of parts from the Foundry, Sheet Metal, Heat Treat and Engines are a regular feature. The testing of raw materials is another vital function undertaken by the Laboratory.

The Factory has in addition, its own experienced Test Pilots and its own airport and Sea Plane landing base.

Having described the Research, Development and testing aspects of aircraft manufacture at HAL, it would not be out of place to any a word about the production set-up. Each manufacturing project is fully preplanned from all the production aspects such as process planning, material planning, time control and so on. This, therefore, makes it possible for the factory to embark on any new project on a pre-determined basis as is the case elsewhere in industrially advanced countries for the manufacture of equipment under modern production line methods.

FUTURE PRODUCTION PLANS

From now on, the main emphasis at HAL will be on MANUFACTURE—writ large. The function of repair/overhaul is to be eventually concentrated at Barrackpore. In fact with the growing stress on manufacture, a position is visualised when in due course the work of overhaul/repair may be distributed among sub-contractors as suitable ancillary industries spring up.

The latest production picture is, that apart from the HT—2 which has been under commercial production for some time now, D. H. Vampire Jet Fighters as well as Trainers are rolling out of the Factory's production line for the IAF.

As for the future, keeping in step with the latest developments in the field of aviation production, HAL will shortly be launching upon a new lines of manufacture—more up-to-date jet fighters. As already referred to plans have been finalised for the production under licence, of Folland's modern light jet fighter, the 'Gnat' and its power plant, the Bristol Orpheus Jet Engine. The factory buildings for these two projects are fast nearing completion. Preliminary work is already under way and production plans are being co-ordinated with the team of Bristol experts now on deputation to the Factory, and according to present expectations, the first Indian built 'Gnat' and the Orpheus Engine will be available within the second five year plan period itself, that is by about 1961.

At the same time plans having already been finalised, work is progressing steadily on the development of an advanced Jet Trainer, a modern medium transport aircraft etc.

But simultaneously with its programme of manufacture there is no doubt that HAL will continue to function, in the future, as in the past, as the main repair and overhaul organisation of aircraft—Military and Civil—Indian and overseas—in this part of the world.

CONCLUSION

In the short span of seventeen years, from being a repair, overhaul and assembly depot, HAL has grown into an important unit of manufacture, unique of its kind anywhere between Cairo and Tokyo, to meet not only the Defence and Civilian requirements of India but also to market some of its products overseas and make its specialised services available to overseas customers. It has, over the past several years, acquired a reputation and set up a tradition which have assured for it a high place among the aircraft industries of the world.

For HAL, the future is full of promise and opportunity. As its manufacturing activities expand and new projects succeed another, it is to be hoped that it will be enabled to take its due place and play its part in world commerce—commercial aircraft production.

Fifteen years later, the clock is coming a full round again to-day with the man-power strength of the factory standing at nearly 12,000; and as the factory expands, the peak figure of 15,000 reached in 1943 bids fair to be eclipsed and even surpassed. The main factory today extends over hundreds of acres of land and hundreds of new acres are being added to it. New buildings to house new projects are fast springing up and within the next few years, with a huge housing colony accommodating all its thousands of employees within its periphery, Bangalore is destined to become the biggest aviation city anywhere to be found in the East.

In no other field of human endeavour in India has there been such a phenomenal evolution as in the case of our aircraft industry, which in step with the rest of the world, has now entered the era of jet production. So bewilderingly rapid and so sudden are the changes that are overtaking this industry that it seems that even the jet age itself may soon become obsolete, as the age of missiles and rocket propulsion is not far off. So in the coming years, India's Aircraft Industry will have all its resources fully stretched and all its energies fully bent upon keeping abreast of the latest developments in the field of aviation. Consequently, it is not too much to say that HAL will be one of the most vital national organisations in India giving full scope for the free play of indigenous initiative and enterprise and destined to play a major role in the future of India.

RAILCOACH AND BUS BODY MANUFACTURE AT HAL

In yet another important sphere of national production, namely, surface transport, HAL has been making a very sizable contribution—the manufacture of all metal Railway Coaches for the Indian Railways —a revolutionary development unknown before in India. HAL's decision to embark on this new subsidiary project was approved by the British Technical Aircraft mission in 1946 along with its recommendation that HAL should be developed into a centre for future aircraft production in India.

By and large, in the west, Railway Coach construction preceded aircraft construction whereas HAL starting from aircraft construction took up railcoach manufacture. Thus it was able to apply aircraft design principles to railcoach building. The extent of HAL's contribution to India will be appreciated when it is realized that immediately after World War II the coaching stock of the Railways had dwindled to a parlous state leading to lack of adequate trains,

A view of the modern all-metal 3rd Class Broad Gauge Rail Coach Assembly line.

overcrowding etc. By its newly designed railcoach perfected in consultation with the Railway Board, HAL has ushered in a renovation in Third Class Travel on Indian Railways and travel by these coaches is comfortable to the point, one may say, of luxury.

As many as one thousand coaches and over have so far been produced by HAL and are operating with the Railways. The present production capacity of the factory is 18 coaches per month which is to be stepped up to one each per day.

The Production of military coaches is also under way.

The next project under HAL's programme of expansion is the manufacture of broad gauge integral coaches in collaboration with M. A. N., a leading railcoach manufacturing firm in Germany. It is expected that within the next five years, HAL would be turning out 300 coaches per annum. The first integral coaches are expected to roll out of the production line at the rate of five coaches from October, 1958.

It may be mentioned that HAL has been a pioneer in this sphere of transport as well as in aircraft construction. The Integral Coach Factory at Perambur which has only recently come into the picture is producing coaches according to a Swiss design.

Linked-up with railcoach manufacture, HAL has been producing pre-fabricated all metal bus body-kits for the various major Road Transport Organisations in India. HAL was until recently producing buses, single and double deckers, out of these pre-fabricated kits but has now given over this line to other firms under Licence Agreements in order to accommodate its other future development plans.

The World's First Vertical Take-Off Airliner

(Specially Contributed to J. O. I. E. Aviation Number)

THE design of the Fairey Rotodyne vertical take-off airliner is based on the results of a wide survey of operators' requirements and makes possible, for the first time, the planning of economical air services from city centre to city centre or freight and passenger operations from small unprepared spaces in undeveloped areas.

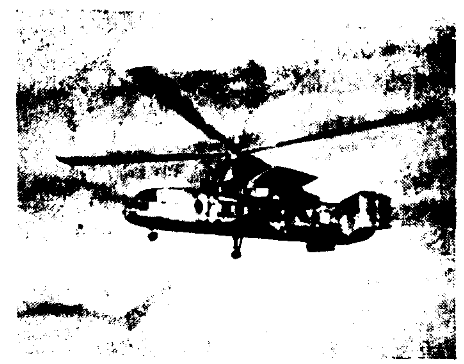
On inter-city operations it can cut out the wasted time spent in road travel to and from aerodromes, whilst in areas where there are not already proper airfields, the Rotodyne offers the ability to take-off and land from small areas. Where roads are poor or non-existent, the Rotodyne, with its box-section fuselage and wide rear-loading doors, is particularly suitable for the rapid transport of passengers and freight.

The Rotodyne is essentially a 48-passenger twin-engined airliner with the vertical flight capabilities of a helicopter. It has all the advantages of a fixed-wing aircraft, such as good forward speed, economical payload, lack of vibration, twin engine safety, simple maintenance and the ability to fly at night and in all weathers.

Current I. A. T. A. requirements for helicopters are met, and improved upon, without any performance restrictions. Such routes as Malaya or the islands of the West Indies could be served at the design gross weight in ambient temperatures up to I. S. A. plus 15°C. Single-engined performance is more than adequate, which means that with both engines operating there is a considerable reserve of power available.

The Rotodyne has an all-up weight of just over 17 tons and can carry 40 passengers (48 with high-density seating) or 4½ tons of freight over ranges of up to 315 miles at a cruising speed of 160 knots. With a reduced payload it has a maximum range of 450 miles.

The power units are two Napier Eland propeller-turbine engines mounted on a stub wing of 46 ft. 6 in. span and driving normal forward-facing propellers. In addition a 90 ft. diameter four-bladed rotor is mounted well above the fuselage. The rotor



Fairey Rotodyne First Flight 6th November, 1957.

Fairey Rotodyne on its Maiden Flight 6th November, 1957 at White Waltham Aerodrome, Berkshire.

blades are of stainless steel and each blade has a Fairey pressure-jet unit at its tip. For vertical take-off compressed air from auxiliary compressors on the Eland engines is piped up to the rotor head and along the blades to the tip jet units, where it is burned with fuel to give jet thrust. The resultant lift from the jet-propelled rotor takes the Rotodyne into the air vertically as a helicopter. Each auxiliary compressor serves one diametrically-opposed pair of jet units and this, in conjunction with similarly duplicated fuel services, minimises power loss in the event of failure of one engine. This system of ducting compressed air to jet-propulsion units at the rotor blade tips dispenses with the gears, shafts and clutches inseparable from an orthodox helicopter. Other major advantages are freedom from the vibration associated with a shaft-driven helicopter; a clear and unobstructed fuselage, since the entire propulsion

(Continued on page A.33)

GAMD MARCEL DASSAULT

By A Technical Correspondent

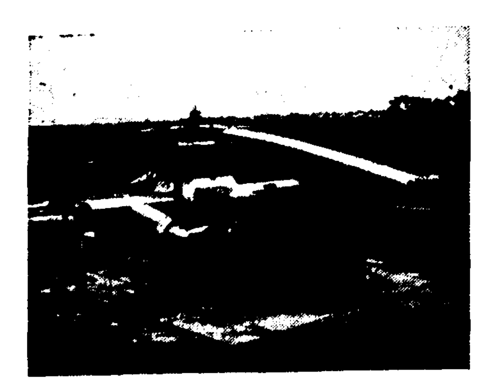
CHRONOLOGY

SHORTLY after the end of the first world war, Marcel DASSAULT resumed his activities in the Aeronautical Industry. From 1915 to 1918, he had already distinguished himself as a young engineer. His work was mainly devoted to multi-motors of all tonnages. He soon obtained large orders for the Air Force and the Navy and also commercial aviation orders. The aircraft were constructed in astonishingly short times in his BOULOGNE and then in his COURBEVOIE factory. This gave his organization " La Societe des Avions Marcel BLOCH " one of the leading positions in the French Aeronautical Industry, with regard to reconnaissance and bomber planes. These aircraft which were then extremely modern in conception, constituted a large part of the equipment of the French armed forces until 1940, and the commercial versions of these craft were being used on European lines.

In 1937, the factories of the Societe Marcel BLOCH were incorporated in the nationalized SNCASO, but Marcel DASSAULT immediately created a new Co. which made it possible for him to continue his independent activities. The Research and Development Department and the production facilities of this Co. together with the TALENCE and SAINT-CLOUD factories and after 1944, the BOULOGNE, ARGENTEUIL and MERIGNAC factories formed the nucleus of the Societe des AVIONS MARCES DASSAULT, which was the forerunner of the present G. A. M. D. of which the industrial capacity is still being expanded.

(Continued from page A.32)

system is mounted in or on the wing; and the ability to operate safely should one engine fail. When sufficient height has been gained after take-off the auxiliary compressors are de-clutched and engine power is transferred to the forward-facing propellers. The Rotodyne then flies forward as a normal aeroplane with the rotor auto-rotating (or " free-wheeling ") and sharing the lift with the fixed wing. For landing, the sequence is reserved: as flight speed is lowered, the propeller pitch is reduced, the auxiliary compressors are engaged, rotor pitch increased and the tip-jets ignited for the descent.



The Fairey Rotodyne rotor on the spinning rig at the Ministry of Supply's Aircraft and Armament Experimental Establishment at Boscombe Down, Wiltshire, England, where the entire propulsive system is being tested prior to the first flight of the Rotodyne.

The first prototype made its maiden flight on November 6th 1957 at White Waltham, Berkshire, England. It was piloted by Fairey's senior rotary wing test pilot S/Ldr. Ronald Gellatly, A. F. C. who was born at Dunedin, New Zealand.

On this aircraft the engines are two Napier Eland N. El. 3 propeller-turbines, each rated at 3000 e. h. p. The second prototype, which is now being constructed, will have a longer and deeper fuselage and will be powered by two Eland N. El. 7 engines giving 3500 e. h. p. each. These engines will be the power units for future production aircraft. There is no doubt that the Rotodyne is one of the most advanced aeroplane concepts flying anywhere today. Its offer of cheap and quick transport which is independent of roads, railways or costly aerodromes will be of inestimable benefit to countries through the world. Where poor ground communications constitute a severe brake on progress at present, the Rotodyne could provide an immediate solution, permitting development at a rate limited only by the capital investment available.

Shortly after the end of the second world war, these factories were producing the variable pitch propeller MD400 intended for the "Languedoc" and the MD304 propeller for equipping the MD315 "Flamant". This was the first post-war assembly-line production to be undertaken by Marcel DASSAULT.

During this same time, an important equipment reconversion program was undertaken, and modern, powerful machines were placed in all the factories. It was with this excellent industrial organization that the OURAGAN, the first assembly-line jet aircraft in France was produced, as well as the various MYSTERE aircraft, the first French plane to pass the sound barrier, first in dive and then in horizontal flight. Large mass production has now been established for the MYSTERE, and besides equipping the French Air Forces, it is used by the air forces of several foreign countries. It has also been chosen by OTAN for the European Defence Program.

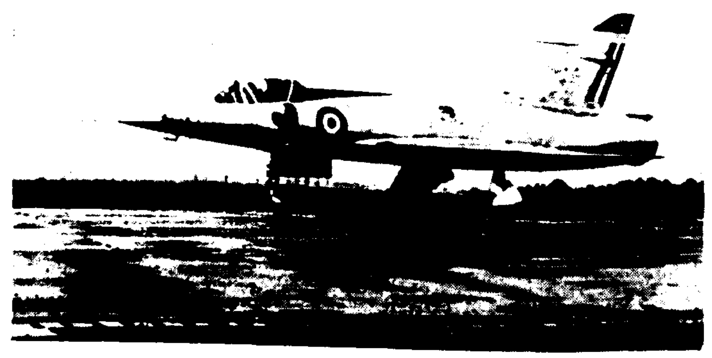
ORGANIZATION

In January 1956 the various facilities of "Avions Marcel DASSAULT" were grouped together under a single company "LA GENERALE AERONAUTIQUE MARCEL DASSAULT". The activities of this organization cover the entire aeronautical field.

S. A. R. L. :	Capital 900,128,000 francs.
Central Office :	78, quai Carnot, SAINT-CLOUD.

BOARD OF MANAGEMENT

Board of Management :	
Management Representative :	M. Vallieres.
Production Manager :	M. Guibert.
Technical Manager :	M. H. Deplante.
Asst. Technical Manager :	M. J. Cabriere.
Test Flight Manager :	M. S. Dassault.
Commercial Managers :	MM. Esperon, Gallois, Mansuy, Sels.
Head of Personnel :	M. Le Bail
Administrative Director :	M. Simon.
Factory Managers :	MM. Curvale, Barriere, Carol, Robert.



A view of the aircraft manufactured at GAMD MARCEL DASSAULT

PRODUCTION

Factories :	
Saint-Cloud :	Prototypes and pre-production of aircraft, jet engines, equipment.
Melun-Villaroche :	Tests on prototypes and Jets.
Argenteuil :	Assembly-line aircraft, propellers, electronics, plastics.
Boulogne :	Prototype components, pre-production and assembly-line.
Talence :	Assembly-line components.
Merignac :	Prototypes, assembly-line, final assembly.
Entire roofed-in area :	140,000 m².

PERSONNEL

5,000 persons directly employed, including 500 engineers and technicians.

G. A. M. D. pilots :	
Villaroche :	
M. Glavany :	Chief Pilot. Asst. Manager Test Flights.
M. Boudier :	Test Pilot.

★

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I, T. S. Nagaraja Rao, hereby declare that the particulars given above are true to the best of my knowledge and belief.

(Sd.) **T. S. Nagaraja Rao,**
Signature of Publisher.

Dated: 1—3—1958

M. Muselli : Test Pilot.
M. Saget : Test Pilot
Merignac.
M. Brian : Chief Pilot.
M. Suisse : Test Pilot.
M. Tixador : Acceptance Pilot.
M. Rastel : Acceptance Pilot.
M. Buge : Acceptance Pilot.

PRODUCTION DURING PAST TEN YEARS

1,200 assembly-line produced aircraft delivered, having completed half a million hours of flight. Final assembly capacity of the Merignac Factory : 35 aircraft per month (with a single shift).

ACTIVITIES

Research and Development : Work carried on in all fields.

Prototypes : Development and construction of various types, in accordance with financial possibilities of the Co., the specific requirements of the Country and the export possibilities.

Assembly-line : Establishment of the production line for executing orders on schedule and at lowest price, while at the same time planning for a regular employment of the worker personnel of G. A. M. D. and of co-operating organisations.

ASSEMBLY-LINE

Aircraft Department : Mystere IV A, Super Mystere B 2.

Jet Engine Department : MD-30 Viper with or without P. C.

Equipment Department : Marcel Dassault Servo Controls.

PROTOTYPES BEING TESTED

Aircraft Department : Etendard IV. Etendard VI, Mirage III.

Jet Engine Department : Turbojets R-7 (1,400 kg. thrust).

Electronics Department : Aircraft radar, Air communications and telecommunications, Servo Equipment.

PROTOTYPES IN CONSTRUCTION

—Etendard VI 02 and 03 (Otan Program).
—Etendard IV M (for French Aeronavale).

RESEARCH AND DEVELOPMENT

Mirage IV.
Missiles.
Aircraft Radar.
Electronic Servo Controls.

NEW ULTRA-SOUND FAULT FINDER

Soviet specialists have devised a new method of ultra-sound defectoscopy. It is based not on the reflection of sound waves, but on through "sounding out" similar to the translucency of the material by relatively low frequency oscillations of 160,000 hertz.

The new method of control makes it possible to check rough or rust-covered articles. The results are registered by an oscillograph. The sensitivity of the new fault-finder is very high and it can check up to 35 square metres per hour with a full guarantee of detecting any defect at any depth.

The new instrument is suitable for control in mass production shops.

The Role of NYVIN CABLES in the Aircraft Industry

Lightest known Cables ever produced

NYVIN CABLES have been introduced recently, and they have been designed, in collaboration with the aircraft industry of the United Kingdom, to provide cables of smallest possible dimensions with weights reduced to a minimum. They are, in fact, the lightest cables possible, with present day known materials, and are more than capable of withstanding installation and service conditions.

NYVIN CABLES conform to British Standards Specification E. 24 (Nyvin type electric cables for aircraft) and are equivalent to cables produced to U. S. A. Military Specification MIL—W—5086 with the exception that the conductors are composed of tinned copper strands in accordance with British practice.

The general construction of NYVIN CABLES is as follows, *viz*—The copper conductors, made up of tinned copper wires bunched or stranded, are insulated with a hard grade of P. V. C. (polyvinyl chloride), over which is applied a glass fibre braid and then a braid of nylon ribbon. Finally the cable is clear nylon lacquered overall.

Whilst all sizes can be manufactured to the above specification the smaller sizes may have a concentric nylon sheath in lieu of the nylon braid and lacquer.

The following types of cable are available, namely :—

(a) UNINYVIN (as table 1.)

(b) UNINYVINMETSHEATH (as table 2.)

(c) UNINYVINMET (as table 3.)

Nyvin cables are classified and identified not by current ratings but by a series of numbers indicative of the cross sectional area. These numbers correspond to those used for equivalent American cables. The current ratings for Nyvin Cables are the same as those for Pren cables (B. S. E21) of the same conductor size.

Cable No.	Equivalent Unipren Size
22	4
20	6
18	9
16	12
14	18
12	24
10	35
8	50
6	70
4	100
2	135
1	150
0	170
00	200
000	230
0000	280

MAXIMUM OPERATING CONDITIONS

Maximum service voltage between conductors or conductor to frame	600 volts r.m.s.
Maximum service frequency	1600 c/s.
Maximum working temperature	90° C.
Minimum working temperature for fixed installations	(minus)—75°C
Minimum working temperature where cable is subject to flexing	(minus)—30°C.

The P. V. C. compound used for insulation is of a hard grade to minimise deformation at elevated temperatures.

The P. V. C. compound is specially prepared with a view to giving fire-resisting properties, it will not burn nor support combustion and, therefore, will not contribute to the spread of fire.

After five days at 120 deg. C. cables will withstand the bend test followed by the normal voltage test of 1500 volts (r. m. s.) for five minutes. At normal temperatures cables may be flexed and bent round a mandrel three times the cable diameter without damage, and pass a bend test at—30 deg. C. on a mandrel ten times the cable diameter.

Cables are resistant to all engine oils including ester-based lubricants kerosene, high-octane fuels and hydraulic fluids, without cracking or swelling of the insulation occurring.

TABLE 1 UNINYVIN CABLES

Cable Number	Number and Diameter of Wires	Nominal Area			Nominal Overall Diameter of Conductor	Maximum Conductor Resistance at 20 deg. C.	Overall Diameter of Cable		Approx-imate Weight
Uninyvin	inches	sq. inches	circ. mils.	sq. m/m	inches	Ohms/100 ft.	Min. inches	Max. inches	lbs. 100 ft.
22	19/.006	.00054	687	0.347	.031	1.655	.080	.090	0.5
20	19 .0076	.00087	1095	0.556	.039	1.032	.090	.100	0.7
18	33/.0076	.00150	1910	0.966	.050	0.594	.105	.115	1.0
16	40/.0076	.00180	2292	1.17	.058	0.488	.115	.130	1.3
14	70/.0076	.00320	4075	2.05	.075	0.280	.135	.150	2
12	110/.0076	.00500	6370	3.22	.093	0.178	.155	.170	3
10	73/.012	.00822	10470	5.33	.118	0.108	.185	.200	4
8	120/.012	.01325	16870	8.76	.161	0.066	.235	.255	7
6	182/.012	.02060	26230	13.3	.209	0.043	.290	.310	11
4	294/.012	.03350	42660	21.5	.263	0.027	.350	.370	17
2	203/.018	.05250	66860	33.3	.333	0.0172	.425	.445	25
1	248/.018	.06300	80220	40.7	.372	0.0141	.470	.495	31
0	323/.018	.08180	104200	63.0	.425	0.0108	.525	.550	39
00	416/.018	.10600	135000	68.3	.475	0.0084	.580	.610	50
000	513/.018	.13150	167400	84.2	.533	0.0068	.650	.680	61
0000	666/.018	.17000	216500	109.0	.590	0.0053	.720	.750	79

TABLE 2 UNINYVINMETSHEATH CABLES

Cable Number	Number and Diameter of Wires	Nominal Area		Nominal Overall Diameter of Conductor	Maximum Conductor Resistance at 20 deg. C.	Overall Diameter of Cable		Approx-imate Weight
Uninyvin-metsheath	inches	sq. inches	circ. mils.	inches	Ohms/100 ft.	Min. inches	Max. inches	lbs. 100 ft.
22	19/.006	.00054	687	.031	1.655	0.115	0.130	1.3
20	19/.0076	.00087	1095	.039	1.032	0.125	0.140	1.5
18	33/.0076	.00150	1910	.050	0.594	0.140	0.155	1.9
16	40/.0076	.00180	2292	.058	0.488	0.145	0.170	2.4

TABLE 3 UNINYVINMET CABLES

Cable Number	Number and Diameter of Wires	Nominal Area		Nominal Overall Diameter of Conductor	Maximum Conductor Resistance at 20 deg. C.	Overall Diameter of Cable		Approx-imate Weight
Uninyvin-met	inches	sq. inches.	circ. mils.	inches	Ohms./100 ft.	Min. inches.	Max. inches.	lbs./100 ft.
14	70/.0076	.00320	4075	.075	0.280	.165	.190	3
12	110/.0076	.00500	6370	.093	0.178	.185	.210	5
10	73/.012	.00822	10470	.118	0.108	.215	.240	7
8	120/.012	.01325	16870	.161	0.066	.265	.295	10

TABLE 4

NYVIN CURRENT RATINGS—CONTINUOUS

NYVIN	Maximum continuous rating in amperes for cables bunched in free air			
	1 cable	3 cables	7 cables	12 cables
22	9½	6	4½	3½
20	12	8	6	4½
18	16	11½	9	5
16	18	13	9½	6
14	27	21	15	10½
12	38	26	19	13
10	48	37	28	20
8	70	52	40	29
6	100	76	57	—
4	140	105	80	—
2	175	135	105	—
1	195	145	115	—
0	210	165	145	—
00	240	185/210*	165†	—
000	260	205/230*	190†	—
0000	290	230/260*	215†	—

* The higher rating is for 2 cables only.
†This rating is for 5 cables only

TABLE 5

NYVIN CURRENT RATINGS—FIVE MINUTES

NYVIN	Maximum 5 minute rating in amperes for cables bunched in free air.			
	1 cable	3 cables	7 cables	12 cables
22	10½	7	6	3½
20	14	10½	8	7
18	20	15	11½	10½
16	22	17	12	11½
14	32	25	21	18
12	44	33	28	26
10	54	46	40	38
8	79	67	61	60
6	125	100	96	—
4	200	165	155	—
2	270	230	220	—
1	290	260	250	—
0	320	305	300	—
00	370	360	350‡	—
000	410	400	400‡	—
0000	470	465	465‡	—

‡This rating is for 5 cables only.

TABLE 6

NYVIN CURRENT RATINGS—ONE MINUTE

NYVIN	Maximum one minute rating in amperes for cable bunched in free air.			
	1 cable	3 cables	7 cables	12 cables
22	13	10½	8	8
20	19	17	13	13
18	26	23	17	16
16	29	25	23	22
14	44	41	38	37
12	63	59	54	52
10	81	79	77	74
8	133	127	125	118
6	220	206	200	—
4	340	330	315	—
2	475	465	455	—
1	545	525	515	—
0	615	605	595	—
00	710	700	690‡	—
000	805	795	—	—
0000	920	910	—	—

‡This rating is for 5 cables only.

Manufacturers :

RIST'S WIRES & CABLES LTD.,
LOWER MILEHOUSE LANE,
NEWCASTLE, STAFFS.

Agents in India :

HILL, ELLIOTT & CO., PRIVATE LTD.,
WAVELL HOUSE, GRAHAM ROAD,
BALLARD ESTATE, BOMBAY.

OIL TANKS BUILT OF SHEET STEEL ROLLS

Very recently it [illegible] to build an oil tank. Scaffolds had [illegible] for this purpose and then steel sheets were fitted to each other and welded on the work-site. If a welder failed to produce a good seam the latter could "explode" when the tank was being filled. It happened that the oil gushing from the tank flooded settlements which threatened to catch fire and inflict enormous losses.

The tanks are now made of sheet steel in plants and delivered to the construction-sites by rail. A tank with a capacity of 2,000 cubic metres can be built in one day.

This progressive Soviet method used for the first time in world practice has great prospects. It considerably improves the quality of oil tanks, makes them more dependable and greatly reduces the labour consuming building processes.

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AUTOMATION OF METALLURGICAL AGGREGATES

The Dniepropetrovsk Iron and Steel Works (Ukraine) has completed tests of a new system of automatic control of a powerful oxygen installation. Special electronic apparatus mounted on it ensures precise regulation of the processes of obtaining oxygen from the air entering the aggregate, the oxygen being used for steel-smelting in the converter.

The other four oxygen installations of the enterprise are now being equipped with similar apparatus. This will ensure higher efficiency of the equipment of the oxygen station and will release about ten of its service workers. The Works' engineers are doing extensive work in automating the machinery in the blast-furnace, steel-smelting and rolling shops. Two-stage axle ventilators have been manufactured and installed on the Cowper stoves of the sixth blast-furnace. They increased the thermal charge in the stoves. As a result the temperature of blowing has been increased by 100 degrees, the time required for smelting pig iron has been reduced and the expenditure of coke has been cut.

Pneumatic instruments for automatic regulation of feeding liquid fuel in the furnace designed by a group of specialists are now in use in the open-hearth furnace shop. They have improved the thermal regime of the aggregate and accelerated the process of steel-smelting.

Engineers of the Works have introduced more than 200 control and measuring instruments and automatic regulators of the thermal regime last year alone.