VOL. XX. No. 12 DECEMBER 1935

MECCANO MAGAZINE

6D.

GIANT PLANO-MILLING MACHINE
(see page 686)

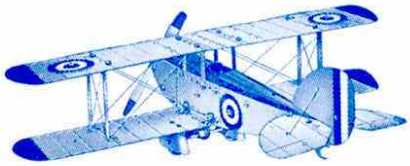
ANOTHER OF MECCANO LTD'S FAMOUS TOYS

No. 1 Aeroplane Outfit. Price 7/6

AEROPLANE CONSTRUCTOR

Boys, building Aeroplane models with these splendid Aeroplane Outfits is great fun! Each model you make is a joy to look at and a delight to play with.

A beautifully illustrated Manual is included in each Aeroplane Outfit showing how to build a number of different models, both monoplanes and biplanes. Many other splendid models may be built by varying the position of the parts, which are all interchangeable on the famous Meccano principle. The parts in the Nos. 1 and 2, 1 Special and 2 Special Outfits can be used in conjunction with the standard Meccano parts.



Model of a Standard Light Biplane built with No. 1 Aeroplane Outfit.

Model of a Commercial Flying Boat built with No. 2 Special Aeroplane Outfit

Price List

Standard Series

No. OO AEROPLANE OUTFIT

This splendid new Outfit contains a good selection of Aeroplane parts with which realistic Aeroplane models can be built. It is an ideal present for young boys who are keen on aeroplanes. Price 3/3

No. O AEROPLANE OUTFIT

An interesting range of models can be built with this Outfit, including high and low wing monoplanes, seaplanes and standard light biplanes. Price 4/6

No. 1 AEROPLANE OUTFIT

Magnificent models of high and low wing monoplanes, and interesting model biplanes representing standard types can be built with this fine Outfit. Price 7/6

No. 1a Aeroplane Accessory Outfit, costing 6/-, will convert a No. 1 Outfit into a No. 2.

No. 2 AEROPLANE OUTFIT

This Outfit enables a much wider range of models to be built, including triple-engined monoplanes and biplanes, and a racing seaplane of the type that was used in the Schneider Trophy Contests. Price 12/6

Note. The parts in the No. OO and No. O Aeroplane Outfits are smaller than those in the other Outfits in the series and are not intended for use with these Outfits.

Special Series

No. 1 SPECIAL AEROPLANE OUTFIT

The parts in this super Aeroplane Outfit will build over 20 realistic models of different types of aircraft. The range of special parts includes mainplanes fitted with ailerons, tail planes with elevators, movable rudder, radial engine cowling, etc. Price 12/6

A No. 1a Special Aeroplane Accessory Outfit, Price 10/-, will convert a No. 1 Special Outfit into a No. 2 Special.

No. 2 SPECIAL AEROPLANE OUTFIT

This is the finest and most attractive Aeroplane Constructor Outfit on the market. It contains a big range of aircraft parts, with which numerous models of practically any type of machine may be built—44 examples are shown in the Manual of Instructions. All the parts that are features of the No. 1 Special Outfit are included, also a number of other parts of special design. Price 21/-

No. 2 Special Aeroplane Outfit. Price 21/-

All Aeroplane Constructor Outfits are available in three different colour combinations.

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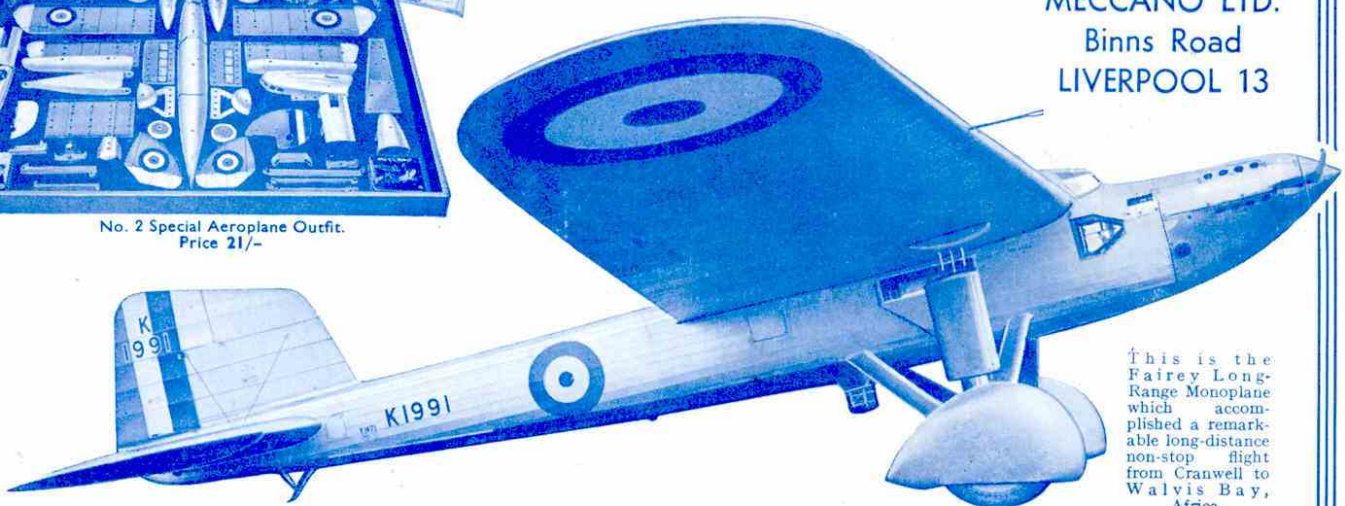
LIVERPOOL 13



This is the Fairey Long-Range Monoplane which accomplished a remarkable long-distance non-stop flight from Cranwell to Walvis Bay, Africa.

Hamleys News

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Containing an electric torch, a clasp knife and a whistle on which is fitted a compass. Post 4d. Price **5/6**

WRITE NOW for our new Annual Catalogue. 80 Pages and Colour Supplement POST FREE.

THE STUDENT MICROSCOPE OUTFIT

High Power instrument. 40 x linear magnification with magnifier, dissecting needles, tweezers and collection jar. (Foreign.) Price **5/-** Post 6d.

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A game of the "Underground." The object is to journey from one station in London to another, avoiding such delays as "Lost Luggage," etc. Post. 6d. Price **5/-**

JASPER MASKELYNE'S BOX OF TRICKS

This box contains a number of superior tricks, specially selected and explained by Jasper Maskelyne, the famous magician and illusionist, so that anyone without previous knowledge can mystify and entertain friends with very little practice. Cabinet complete. Price **15/6** Post 1/-

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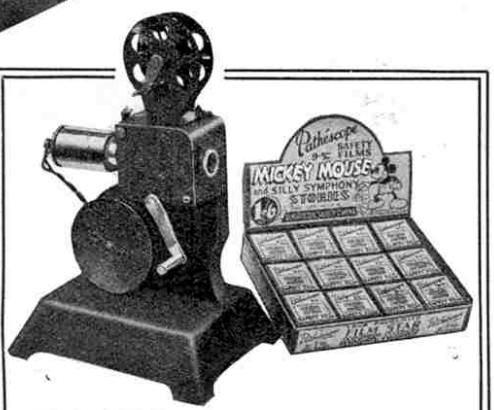

THE NEW 9.5 m.m. PROJECTOR "BINGOSCOPE"

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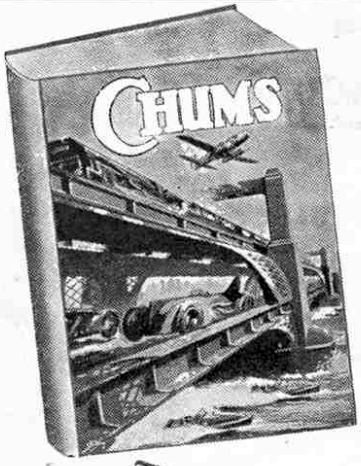
Battery model **17/6** Batteries 1/3 extra. Post 9d.
All Mains model D.C. or A.C. 100 to 250 volts with resistance. Price **27/6**
Mickey Mouse Film: 15 ft. 1/6. 30 ft. 3/9. 60 ft. 6/6

BUILD A REAL SCALE MODEL OF THE "QUEEN MARY"

Scale 1 in.–100 ft. This fine outfit includes ready made hull in one piece, all deck fittings, bridge, funnel bases and lifeboats. Also a transparent showcase 11 ins. long moulded and ebonized base with top decorated imitation sea. Easy to build a model that you will be proud of. Full instructions to assemble. Price **5/-** Post 6d.



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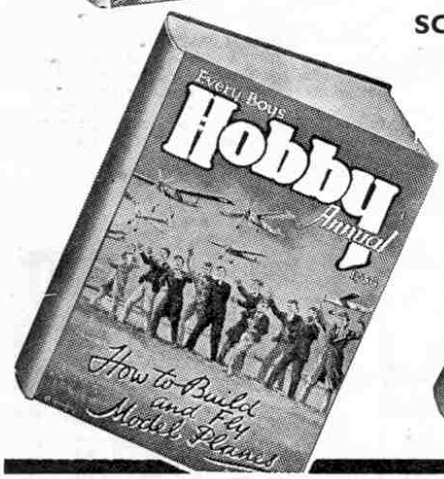

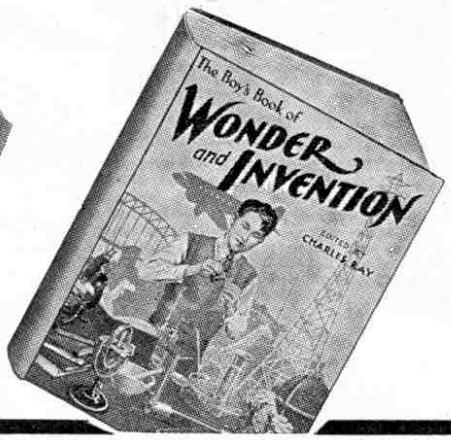

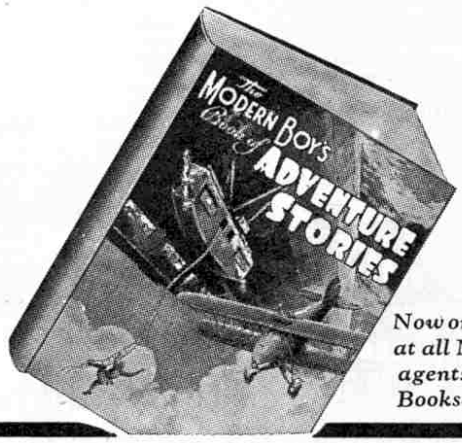

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. . . A Manual for the keen model-builder

The Meccano "Standard Mechanisms" Manual has been specially written to show how almost every machine and movement used in actual engineering can be reproduced with Meccano parts. Nearly 200 mechanisms are illustrated and described in a simple manner, so that you can include them in your own models, making them real engineering structures in miniature.

The Manual can be obtained from any Meccano dealer, price 1/- (New Zealand and South Africa, 1/6, Canada 30 cents).

YOU **MUST** HAVE THIS MANUAL.

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WELL HERE'S A WONDERFUL OPPORTUNITY FOR YOU TO OBTAIN A REALLY USEFUL WATCH BARGAIN

POCKET WATCHES
Nickelled case, imitation engine turned, first-class lever movement, special solid pinions for hard wear, crystal glass, clear dial marked 12 and 24 hours. Very neat appearance and an excellent timekeeper.

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WRIST WATCHES
Chrome nickelled case, first-class Swiss lever movement, extra strong pinions to stand hard wear, patent U.B. glass, clear dial, smart appearance, good timekeeper.

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THE LEAGUE OF NATIONS COVENANT BROKEN!

COUNTRY RESORTS TO WAR!

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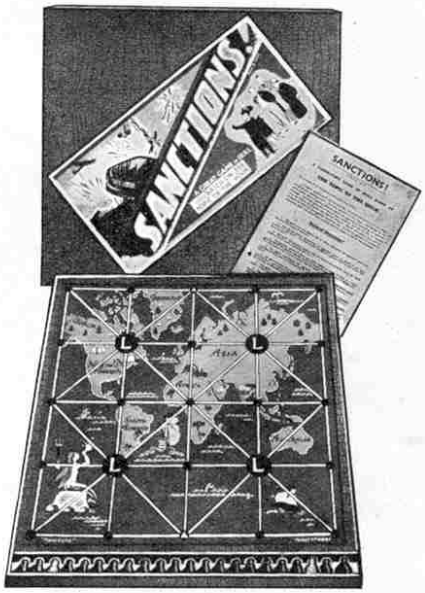
The Covenant of the League of Nations has been broken by a nation resorting to war. The other members of the League are attempting to apply an economic blockade against the aggressor.

One player represents the League of Nations and the other player represents the aggressor. Whether the sanctions succeed or fail depends on the relative skill of the players.



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2/- each

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The above are actual photographs of models built from Aeromodel Construction Sets.

Perfect scale models can be built up from these Kits without special tools or skill. Exhibition standard can easily be attained. In addition to the above, our range includes the following types: De Havilland "Gipsy Moth," "Puss Moth," "Dragon" and "Fox Moth," also Comper "Swift" and Supermarine Schneider Seaplane.

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A broad outline of the development of railway operation, locomotives and rolling stock, by an expert. Modern design is seen against an historical background, and the railway systems of other countries and continents are described.

With 46 illustrations in photogravure.
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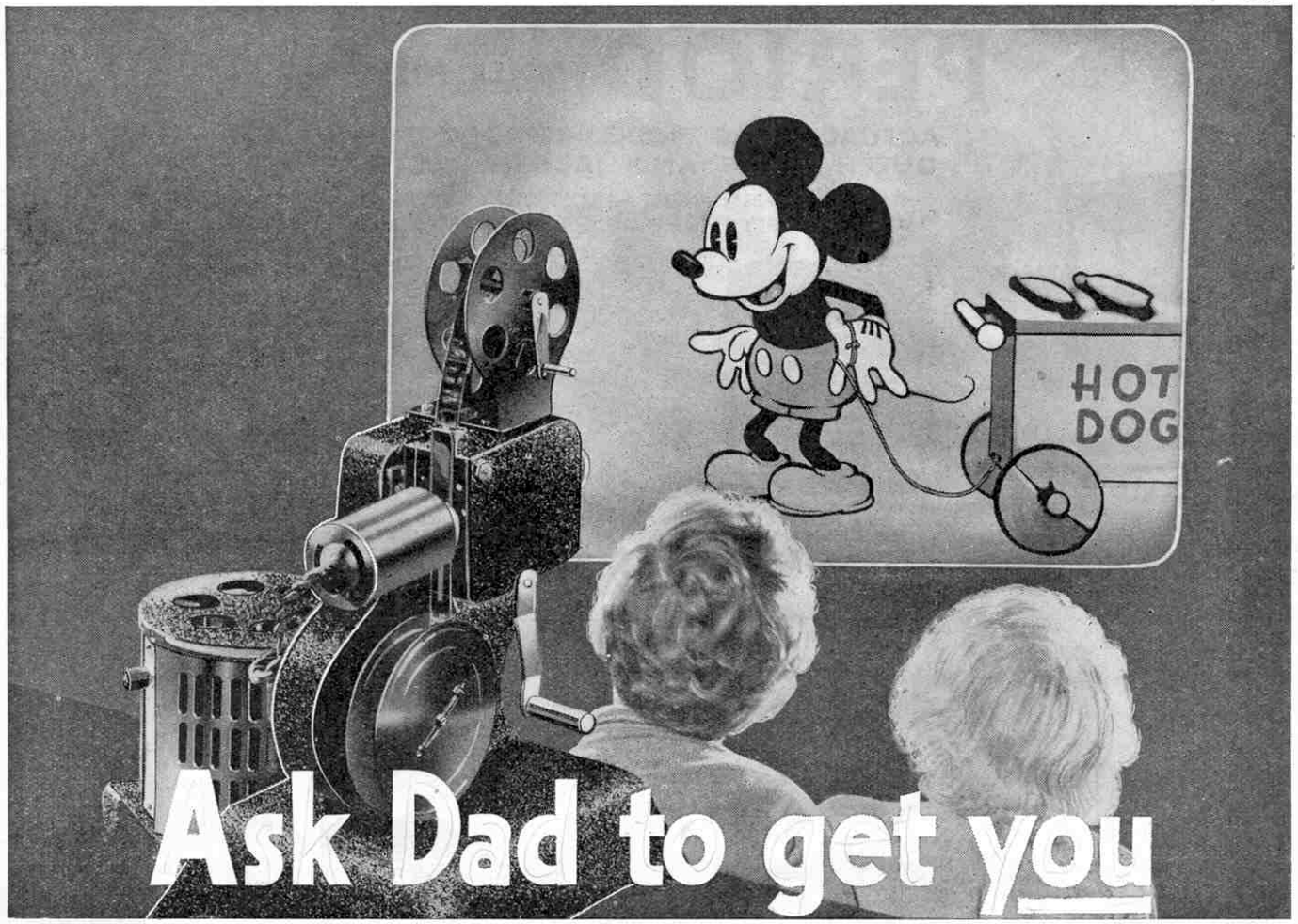

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ALL MAINS MODEL
Works on A/C and D/C 100 to 250 volts.
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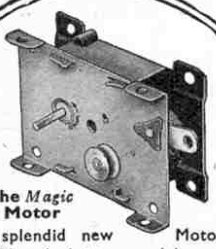


The *Magic* Motor

This splendid new Motor is capable of driving models made with Meccano Outfits A, B and C It costs only 2/–.

MECCANO

MOTORS FOR DRIVING MODELS

If you want to obtain the fullest enjoyment from the Meccano hobby you must operate your models by means of one of the Meccano Clockwork or Electric Motors listed below.

CLOCKWORK MOTORS

The *Magic* Motor (non-reversing) ...	Price	2/–
X Series Motor (non-reversing)... ...	,,	2/–
No. 1 Clockwork Motor (non-reversing)	,,	5/–
No. 1a Clockwork Motor (reversing) ...	,,	7/6
No. 2 Clockwork Motor (reversing) ...	,,	9/–

ELECTRIC MOTORS

No. E1 Electric Motor (6-volt). Non-reversing	Price	9/–
No. E6 Electric Motor (6-volt). Reversing ...	,,	15/6
No. E120 Electric Motor (20-volt). Non-reversing	,,	10/–
No. E20B Electric Motor (20-volt). Reversing	,,	18/6

TRANSFORMERS

The Transformers made by Meccano Limited provide a convenient and safe means of driving 6-volt or 20-volt Electric Motors and Train Sets from the mains supply where this is alternating current.

When ordering a Transformer or a Transformer-Rectifier the voltage and frequency of the supply must be stated. These particulars are given on the supply meter.

No. T6A Transformer (Output 40 VA at 9/3½ volts) for 6-volt Electric Motors or 6-volt Trains. Fitted with speed regulator and separate circuit for supplying current for eighteen 3½-volt lamps ... ... Price 22/6

No. T6 Transformer (Output 25 VA at 9 volts) for 6-volt Electric Motors or 6-volt Trains. Fitted with speed regulator ... ... Price 17/6

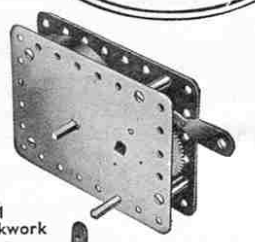
No. T6M Transformer (Output 25 VA at 9 volts) for 6-volt Electric Motors or 6-volt Trains. This is similar to No. T6, but is not fitted with a speed regulator ... Price 12/6

No. TR6 Transformer-Rectifier (Output 6 volts at 1½ Amps.) for use with Hornby No. EPM16 Special Tank Locomotive (6-volt, Permanent Magnet) ... ... Price 29/6

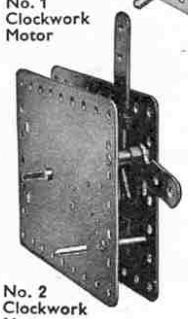
No. T20A Transformer (Output 25 VA at 20/3½ volts) for 20-volt Electric Motors or 20-volt Trains. Fitted with speed regulator and output sockets for lighting lamps. Price 22/6

No. T20 Transformer (Output 20 VA at 20 volts) for 20-volt Electric Motors or 20-volt Trains. Fitted with speed regulator ... ... Price 17/6

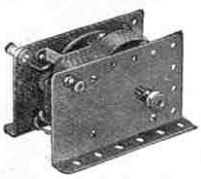
No. T20M Transformer (Output 20 VA at 20 volts) for 20-volt Electric Motors or 20-volt Trains. This is similar to No. T20 but is not fitted with speed regulator... Price 12/6



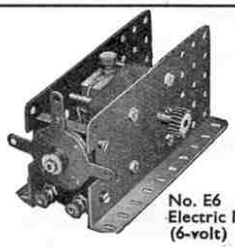
No. 1 Clockwork Motor



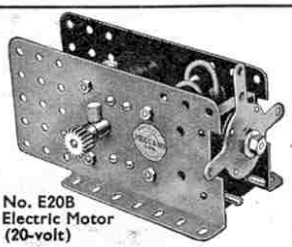
No. 2 Clockwork Motor



No. E1 Electric Motor (6-volt)



No. E6 Electric Motor (6-volt)



No. E20B Electric Motor (20-volt)

No. T20 Transformer

A NEW ELECTRIC LIGHTING SYSTEM

FOR HORNBY ACCESSORIES

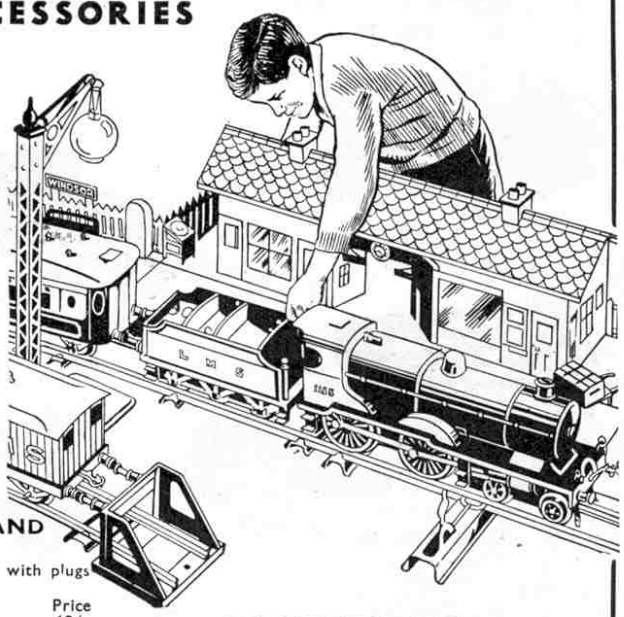
BRILLIANT, SAFE AND INEXPENSIVE

The following is a complete list of the Hornby Accessories available fitted for electric lighting on the new and simplified system adopted this season. These accessories are specially designed for lighting from the 3½-volt circuit of a Meccano T20A or T6A Transformer, and with each of these Transformers are packed for the purpose a pair of Plugs, an Earthing Clip and a coil of Wire, together with full instructions. The Accessories can also be lighted from an accumulator. Each Accessory is accompanied by an Earthing Clip and a Leaflet giving full instructions for use. Lamp bulbs are not provided with the Accessories.

No. E1E Engine Shed	Price 15/6	No. 2E Signal Gantry	Price 12/9
No. E2E Engine Shed	,, 23/–	No. E1E Level Crossing ...	,, 5/3
No. 2E Station	,, 9/3	No. E2E Level Crossing ...	,, 9/–
Island Platform E	,, 6/3	No. 1E Buffer Stops	,, 1/6
No. 2E Goods Platform... ...	,, 11/6	No. 2E Buffer Stops	,, 6/–
No. 2E Signal Cabin	,, 4/3	No. 2E Water Tank	,, 6/6
No. 2E Signal	,, 2/9	No. 1E Lamp Standard	,, 2/11
No. 2E Double Arm Signal ...	,, 3/11	No. 2E Lamp Standard	,, 3/3
No. 2E Junction Signal	,, 6/–		

The following items used in connection with the new system of Accessories lighting are available:

Plugs for sockets of Transformers T20A and T6A ... ... Price per pair, 6d.
Earthing Clips ... ... each 3d. Connecting Wire ... Price per coil 4d.



ACCESSORIES FOR LIGHTING WITH DISTRIBUTION BOX AND FLEXIBLE LEADS

The old type Accessories fitted for lighting by means of a Distribution Box and Flexible Leads with plugs and sockets are still available at the following prices:

	Price		Price		Price
No. E1E Engine Shed ...	18/6	No. 2E Double Arm Signal	6/6	No. 2E Water Tank ...	10/–
No. E2E Engine Shed ...	26/–	No. 2E Junction Signal ...	9/–	No. 1E Lamp Standard ...	3/6
No. 2E Station	11/6	No. 2E Signal Gantry ...	18/–	No. 2E Lamp Standard ...	4/3
Island Platform E	9/–	No. E1E Level Crossing ...	7/–	Flexible Leads, 9", 18", and 36". Prices 1/4, 1/5 and 1/6 respectively.	
No. 2E Goods Platform ...	15/–	No. E2E Level Crossing ...	11/–		
No. 2E Signal Cabin ...	5/6	No. 1E Buffer Stops ...	2/–		
No. 2E Signal	4/3	No. 2E Buffer Stops ...	7/–	Distribution Box ... Price 2/6	

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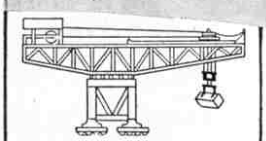
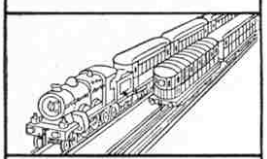
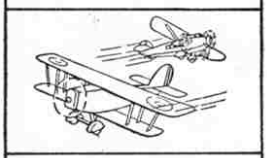


Brimful of Good News for Boys

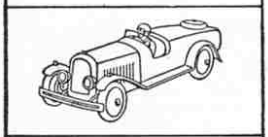


The new "Book of Hornby Trains and Meccano Products" is the finest catalogue we have ever produced. It is beautifully printed in full colour throughout on finest quality white art paper, and its sixty pages contain the complete range of Meccano Products.

On the Meccano Outfit pages are examples of the fine models that can be built with the new-style parts finished in blue and gold. The Hornby Trains section (comprising thirty pages) will delight and satisfy the ever-increasing number of model railway enthusiasts. On other pages are featured Motor Car and Aeroplane Constructor Outfits, Dinky Builder, Kemex Chemical and Elektron Electrical Outfits, Hornby Speed Boats and Dinky Toys.



We hope that every boy in the country, and especially readers of the "M.M.," will make a point of securing a copy of this remarkable production without delay.



HOW TO OBTAIN THE BOOK

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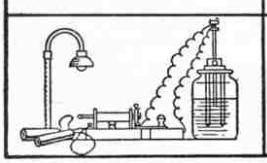
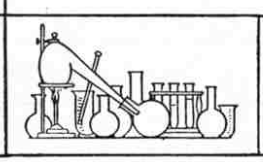
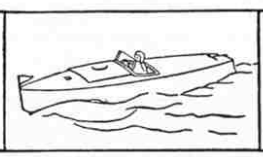
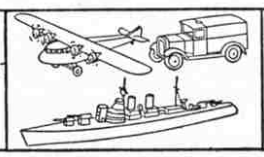
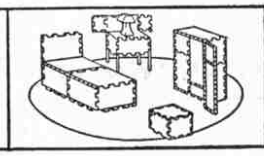






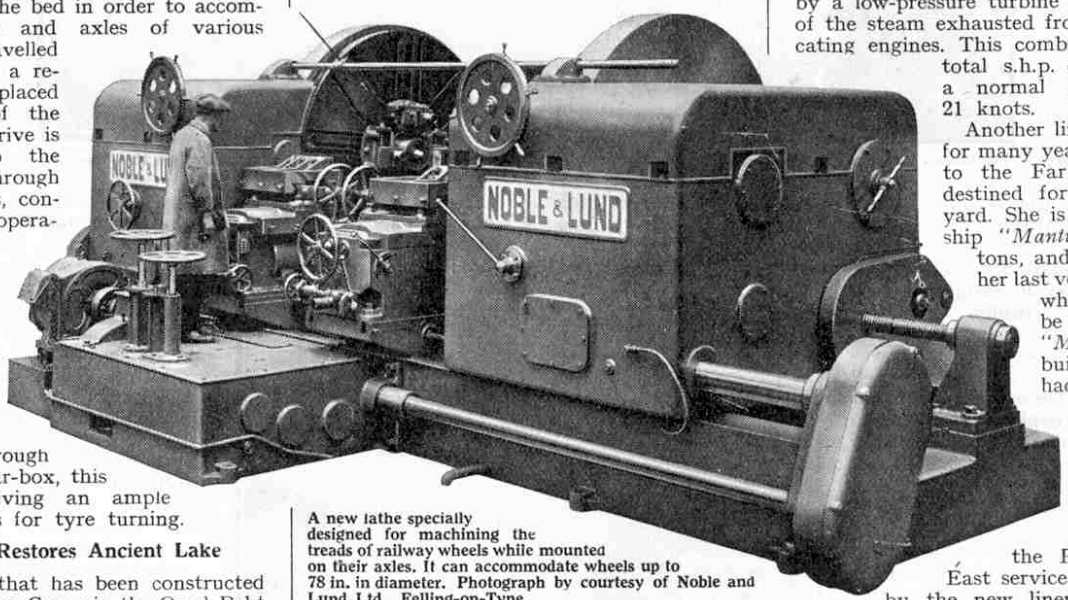




Toys of Quality made by Meccano Ltd. Liverpool

Machining Railway Wheels

The illustration on this page shows a railway wheel lathe that is specially designed to turn either new or worn railway wheels of from 36 in. to 78 in. in diameter, while mounted on their axles. The machine, which is manufactured by Noble and Lund Ltd., Felling-on-Tyne, is provided with two headstocks, each with a driven faceplate 80 in. in diameter, and two saddles. The right-hand headstock can be moved backward or forward along the bed in order to accommodate wheels and axles of various gauges and is travelled by power from a reversing motor placed at the rear of the machine. The drive is transmitted to the headstock through friction clutches, controlled from the operator's platform. The main drive is provided by a variable-speed 50 h.p. motor, the power of which is transmitted to the various mechanisms through a two-speed gear-box, this combination giving an ample range of speeds for tyre turning.



A new lathe specially designed for machining the treads of railway wheels while mounted on their axles. It can accommodate wheels up to 78 in. in diameter. Photograph by courtesy of Noble and Lund Ltd. Felling-on-Tyne.

New Dam Restores Ancient Lake

A new dam that has been constructed in the El Kansera Gorge in the Oued Beht River, Morocco, has had the effect of re-establishing an ancient lake that had become a dried-up basin owing to the fact that the river had formed a gorge into which the water of the lake drained. The construction of the dam has created a reservoir of 61 thousand million gallons capacity, which is intended for irrigating about 74,100 acres of surrounding country. As the surface of the new lake is at a level of 114 ft. above the river bed, the surplus water not required for irrigation purposes is to be utilised for driving turbines at a hydro-electric station that has been constructed below the dam.

Constructional work on the dam was carried on under the shelter of an upstream concrete cofferdam of arched form and an earth cofferdam downstream, the river water meanwhile being diverted into a concrete lined tunnel, about 11½ ft. diameter and 1,476 ft. long. This tunnel is a permanent structure, and is provided with control valves for the discharge of water to the river below the dam for irrigating purposes.

High Speed British Motor Coaster

During recent trials in the Firth of Forth a new motor coastal vessel, the *"Ocean Coast,"* reached a speed of 13.89 knots over the measured mile, which makes her one of the fastest engaged in the British coastal trade. She is the third of four vessels of a similar type that are being built by Henry Robb Ltd., for Coast Lines Ltd., and will be used on a bi-weekly service between London and Liverpool. The *"Ocean Coast"* has a length of 250 ft., a breadth of 38 ft., and a deadweight carrying capacity of 1,700 tons; and she is propelled by a twin-screw arrangement of two 750 b.h.p. "Atlas" heavy oil engines.

Included in the navigating equipment is an automatic depth recorder, and there is also a complete wireless telegraphy apparatus. In addition to large cargo holds with electrically operated lifting gear, the *"Ocean Coast"* has 12 single-berth cabins and public rooms.

A Record Rotation Speed

What is claimed to be the highest rotating speed ever achieved has been obtained with an experimental mechanism in the United States. The experiment was carried out with a very small centrifuge in which a rotor was rotated by a stream of hydrogen impinging upon a series of flutes. The rotor attained a speed of 1,200,000 r.p.m., and once it was properly running it rested entirely in a bearing of hydrogen.

The Passing of Two Famous Liners

The Cunard White Star liner *"Olympic"* is now being broken up at Jarrow-on-Tyne. This famous ship was built in 1911 at the Belfast yard of Harland and Wolff Ltd., and during her 24 years of service she crossed the Atlantic 500 times. She had a gross tonnage of 46,439, a length of 852½ ft. and a breadth of 92½ ft., and was fitted with triple screws, the outer screws being driven by reciprocating engines and the centre screw by a low-pressure turbine that made use of the steam exhausted from the reciprocating engines. This combination gave a total s.h.p. of 18,000, and a normal sea speed of 21 knots.

Another liner well known for many years to travellers to the Far East is also destined for the breaker's yard. She is the P. and O. ship *"Mantua,"* of 11,000 tons, and recently made her last voyage to Japan, where she is to be broken up. The *"Mantua"* was built in 1909 and had quadruple-expansion engines driving twin screws, giving a speed of 18½ knots. Her place in the P. and O. Far East service is to be taken by the new liner *"Strathmore,"* which was referred to in page 629 of the November, 1935 *"M.M."*

A New French Village

A new village settlement has been developed in France for the treatment of ex-soldiers suffering from tuberculosis. The village, which is about 30 miles from the nearest town, Perigueux, includes about 180 houses, a hotel for 260 persons, a central administrative building, a hospital with forty beds, and a general stores where the inhabitants can procure everything they require, from foodstuffs to furniture. There are also open-air schools, sport grounds, a theatre and a large garage.

The village possesses its own electricity station, which is equipped with seven Sulzer heavy oil engines direct coupled to alternators having a normal output of 635 kW. Five miles from the settlement there is a pumping station which supplies all the water required by the inhabitants.

Motor Ships for Venetian Canals

Four new motor passenger cruisers have been built for use on the canals of Venice. Each vessel has a length of 131 ft., a beam of 24½ ft., and a maximum speed of 12.9 knots, and is propelled by a 525 h.p. Fiat six-cylinder engine. The engine room occupies the full breadth of the hull and contains in addition to the main propelling motor, air compressors for supplying starting air to the engines, air storage vessels, electric generator sets driven by oil engines, and pumps. The hull of each ship was built almost entirely by welding, riveting being employed for the hull plating alone. Each ship has a single funnel that is fitted with air slots.

Russian Canals for Large Cargo Ships

If a project that is now under consideration is carried out, Russia will soon possess a splendid canal system capable of bearing large cargo vessels. It is proposed to enlarge an existing series of rivers and canals known as the "Maryinsky Waterway," which connect the Baltic with the Volga, and to extend the system so as to connect Moscow with Leningrad, the Baltic, the White Sea and the Volga. A canal is also to be built to connect the Volga with the Black Sea, and work on this is to be started next year. When it is finished vessels will be able to pass direct from the Arctic to the Black Sea.

Lancashire's Largest Power Station

A new 51,600 kW BTH turbo-alternator that is to be installed at the Kearsley Power Station of the Lancashire Electric Power Company will make this the largest generating plant in Lancashire. Some 18,500 tons of material have been excavated and some 4,000 tons of concrete and 110 tons of steel reinforcement have been put into the foundations on which the alternator will rest. The new machine will be brought into operation in August, 1936.

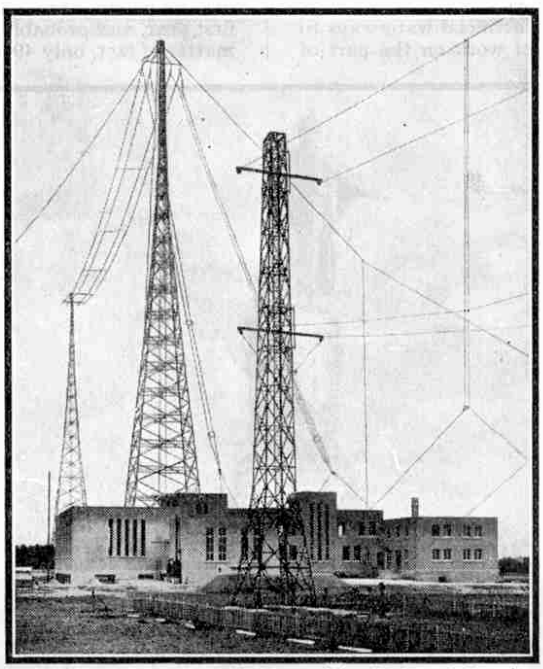
A Tunnel Under the Japan Sea

A new undersea railway tunnel that will be the longest undersea tunnel in the Far East is to be built during the next few years. It will run beneath the Kwannon Straits, the link between the Inland Seas and the Sea of Japan, and will connect Japan's main island, Honshu, with Kyushu. It will be one and two-third miles in length, one mile of which will be under water, at a depth of 120 ft. below sea level and 21.6 ft. below the bottom of the channel, and will be in the form of a tube 28 ft. in diameter.

Boring tests have already been made in the sea-bed, to ascertain the depth, and speed, of the currents.

A Camera with Ten Lenses

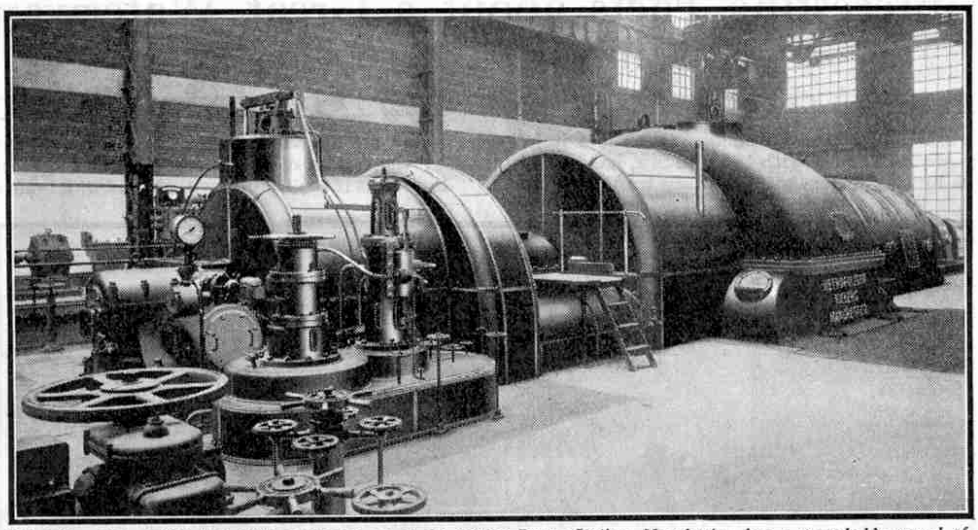
A giant aerial camera that is said to be the largest in the world is in use at the new Boulder Dam, in the United States. The great reservoir behind the Dam is now gradually filling, and the photographs, which are being taken at intervals as the water rises, will be used to provide details for making a contour map of the reservoir basin. The camera consists of two units each containing five lenses fitted with separate shutters controlled from an electric master shutter. Ten prints are taken with each operation of the master shutter and these prints overlap to make a composite print 32 in. by 32 in. From an elevation of 30,000 ft., 760 sq. miles of ground area can be included in the composite photograph. The camera complete with the 10 rolls of film needed for a single loading weighs 275 lb. This amount of film is sufficient for 2,000 separate photographs or 200 composites.



The League of Nations Radio Transmitting Station at Prangins (Vaud). Photograph by courtesy of the "Sulzer Technical Review."

Turbo-Alternator's Fine Record

The history of a Metro-Vick 41,000 kW turbo-alternator at the Barton Power Station, Manchester, provides a striking illustration of the reliability of modern electric supply plants. This plant, which is shown in the upper illustration on this page, was first put into service at the end of 1928, and during 6½ years up to June of this year it ran for 49,468 hours out of a possible total of 57,180 hours, and during that period generated 1,580,908,600 units of electricity. The rotor of the machine is 83 ft. 6 in. in length, and about 100 tons in weight, and during the period mentioned made 4,452,120,000 revolutions. The coal consumed in producing the steam to drive the turbine totalled about 854,000 tons. Recently the machine was stopped for inspection and after a few minor repairs had been carried out was put back into service.



This Metro-Vick 41,000 kW turbo-alternator set at the Barton Power Station, Manchester, has a remarkable record of service and reliability. Photograph by courtesy of Metropolitan-Vickers Electrical Co. Ltd., Manchester.

An interesting comparison may be made between the speed of the blade tips on the largest wheel in the turbine and the speed of the Earth. The speed of the blade tips is 548 m.p.h., while the surface of the Earth in the latitude of Manchester moves round its axis at 625 m.p.h.

Novel Lighting Effects for the "*Queen Mary*"

Among the many novel features of the Cunard White Star liner "*Queen Mary*" will be a wonderful system of kaleidoscopic lighting in the ballroom. The system will be controlled by a special thyratron valve that is being manufactured by the British Thomson-Houston Co. Ltd., and which will enable hundreds of coloured lamps to be alternately dimmed and brought to full brilliance in a pre-arranged sequence, thus producing fascinating and constantly changing colour effects.

Picking Cotton by Machinery

A new device that has been developed in the United States seems likely to replace hand picking of cotton by machine picking. The machine consists of an endless belt to which are fixed hundreds of driven smooth wire spindles. In action the belt is drawn over a row of cotton plants, and the rotating spindles, which are moistened slightly, collect the cotton pods without injuring the plants. The cotton is then stripped from the spindles and delivered by a fan to a storage bin.

Novel Machine for G.P.O.

An ingenious machine for sorting letters is being tried out at Brighton Post Office by the G.P.O. The machine is reported to have an output of 24,000 sorted letters per hour.

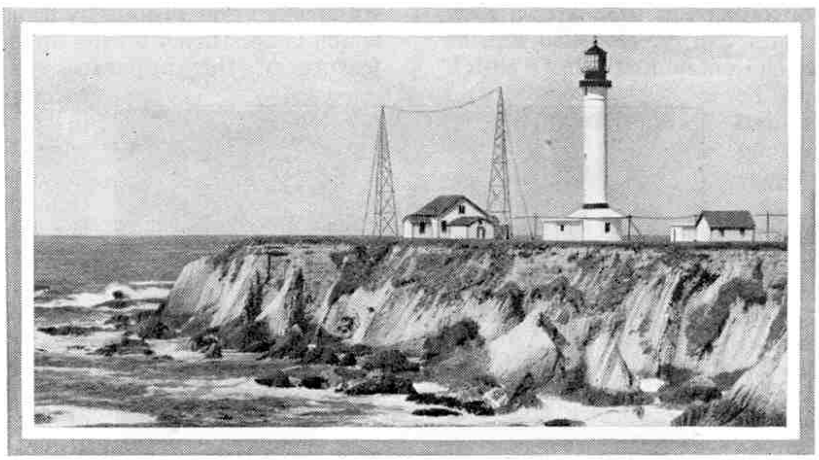
LIGHTHOUSES ALONG the CALIFORNIAN COAST

Strange Incidents of Winter Storms

By Harold J. Shepstone F.R.G.S.

IT has been said of American lighthouses that no two are alike, and there is some truth in this statement. Some of them are built of stone, massive, tower-like erections like those found around our coast; others are of iron or steel, and still others of wood. Many of them are quite attractive edifices, reminding one more of a palatial residence standing on a lonely rock in the sea than of a lighthouse. Nevertheless, they are efficient structures, equipped not only with a powerful light, but with automatic fog signals and the very latest devices for aiding the mariner. Indeed, "Uncle Sam" is now fitting these beacons with radio, which means that in fog or storm a mariner can send out a signal and a few seconds later receive word as to his whereabouts and how best to proceed.

Probably there is no other stretch of coast line where the lighthouses present such an array of different types as are to be found along the Pacific coast of America. Of the 39 beacons along California's 1,000-mile coast no two are exactly alike. Many of them have been erected within the last 10 or 12 years, and they may be said to represent the latest practice in lighthouse building. Some of them are quite novel structures, such as the South Hampton Shoals beacon erected only a few years ago in San Francisco Bay. This is one of the few lighthouses in the world to be built on stilts, and its main work is to warn shipping away from the shallow waters of the Bay. This great square-shaped building, with its many windows, spacious verandahs, and quaint tower, has more the appearance of a seaside hotel than of a lighthouse. The building is carried on iron piles driven deep into the ocean bed, and driving the piles in the open ocean proved no light task on account of the swift currents and choppy seas experienced at this point.



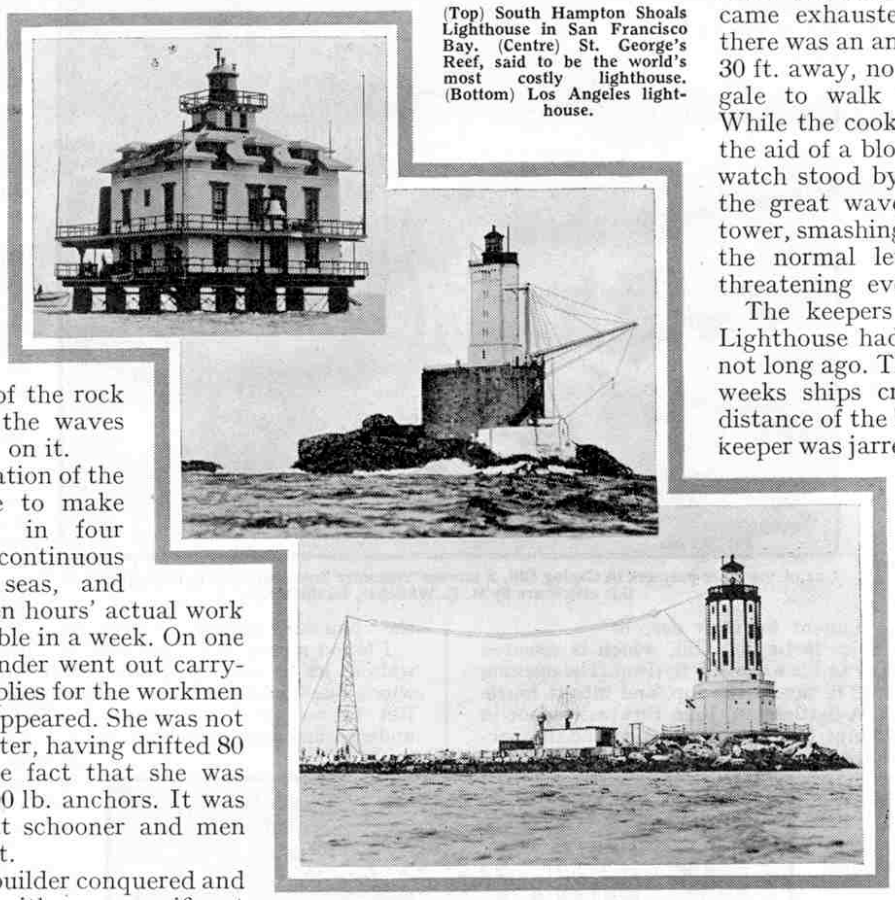
Point Arena, graveyard of Pacific ships, offers every modern aid to shipping in spite of its isolation. Mile Rocks Lighthouse is shown in the heading.

Not far away is the Mile Rocks Lighthouse, which helps to guide ships through the Golden Gate. In this case, however, the beacon rises from a lonely rock. The base is a great circular structure fashioned of massive steel plates, strongly bolted to one another, the interior being filled in with concrete. On this firm foundation, well above the ordinary wash of the waves, rises the lighthouse proper in three successive tiers, the topmost one being crowned with a lantern. The erection of this light on an exposed wave-washed rock proved a difficult undertaking, and occupied three seasons of hard and laborious toil in very trying seas and weather.

One of the sea-builders' greatest triumphs on the coast here was the building of the Tillamook Lighthouse. Tillamook is a small, abrupt rock formation, one mile from the mainland. Its sides are so precipitous and so inhospitable that even in calm weather landing is extremely dangerous, and during the first attempt to put a working party on the rock the foreman lost his life. The first thing the men had to do after they had effected a landing was to drive away a particularly vicious herd of sea-lions! The next step was to erect a shelter made of iron and wood and bolted to the rock. One night a tornado drove the waves completely over the rock, crushing in the shelter in which the men slept, and washing away most of their provisions, and nearly all their tools, clothing and equipment. For days at a time, in the coldest weather of a northern winter, the men were compelled to lie clinging to the slippery rock, drenched with icy water, buffeted by swiftly-succeeding storms of snow and sleet, and lashed by the bitter sea winds. Some idea of the strength of the waves at this spot may be gained from the fact that a few winters ago a boulder weighing 148 lb. was lifted bodily and sent crashing down through the roof of the tower. The lighthouse stands 183 ft. above the breakers, and to reach it one rides upward in a skip—a sort of open-air elevator—suspended from a steel cable. A recent incident reveals the occasional bit of humour with which the many lonely hours spent by the keepers of the light is broken. A somewhat unpopular inspector arrived at Tillamook and climbed into the skip for a ride upward. As his boat pulled away, the iron platform on which he stood suddenly and unceremoniously started a downward movement. It struck the water without halting and immersed the dignified official beneath the waves. He came up spluttering with rage. A second time he was dropped. Again he spluttered, and once more he descended into the sea. This time he held his tongue. Whether any casual relation existed between his expletives and repeated duckings I cannot say, yet it is true that his silence after the third

immersion was followed by swift and safe ascent. The sequel I cannot relate, for no record exists of his conversation with the operator of the skip during the ensuing hour.

What is declared to be the most costly of lighthouses is St. George's Reef, which stands on an isolated rock some 14 miles off the coast of California. It took seven years to build and required an expenditure of £150,000. The rock is so exposed and swept by the seas that the workmen could not safely live on it as they did at Tillamook, and it was necessary to moor a schooner near the rocks to provide quarters for them. They were transported back and forth in a cage suspended from a traveller on a cable one end of which was made fast to the rock and the other to the mast of the schooner. A quick means of getting off the rock was necessary as heavy waves, resulting from offshore winds, would begin breaking on the rock without any local warning, and the sea would rise so suddenly that in three or four hours from a dead calm the crest of the rock would be swept by the waves and no one could live on it.



(Top) South Hampton Shoals Lighthouse in San Francisco Bay. (Centre) St. George's Reef, said to be the world's most costly lighthouse. (Bottom) Los Angeles lighthouse.

At the first examination of the rock it was possible to make only four landings in four weeks. It was a continuous battle with heavy seas, and often only six or seven hours' actual work on the rock was possible in a week. On one occasion when the tender went out carrying the necessary supplies for the workmen the schooner had disappeared. She was not found till four days later, having drifted 80 miles, in spite of the fact that she was moored by two 12,000 lb. anchors. It was thought at first that schooner and men had been entirely lost.

In the end the sea-builder conquered and crowned the rock with a magnificent lighthouse. It stands on a specially prepared foundation, or pier, rising to a height of 70 ft. above the water. Above this is the lighthouse proper, a square granite tower, with a projecting stair cylinder. The lantern with its light is 146 ft. above the sea.

Engineers declare that no storm, however severe, could possibly dislodge this massive-built beacon of interlocking granite blocks on St. George's Reef. Nevertheless, American lighthouses have been seriously damaged by exceptionally heavy gales. One recent storm threatened the destruction of the Los Angeles Lighthouse, a remarkable structure in many ways, built at the end of a rocky finger that extends two miles out into the sea. For five days the wind howled and waves beat at its sides; and when, after the sun reappeared, the keepers dared venture forth into the open, they dropped a weight from the top by a line, and found that the tower leaned in towards the land! To this day it leans away from the sea, as though afraid of more storms to come.

The smallest shipwreck ever recorded by a lighthouse service occurred at the Los Angeles Lighthouse. Three men had put out in a skiff. Green seas broke over the rocks, yet they ventured forth after fish, and did not seem to realise the danger they faced as the tiny craft bobbed about in the wind-lashed waves. Suddenly, without the slightest warning, a swell rolling in from the depths lifted the skiff, dropped it on the rocks beside the light tower, smashed it to smithereens, but left the valiant three unhurt. So hard did the wind blow and the waves lick at the breakwater that the men could not reach shore for two whole days.

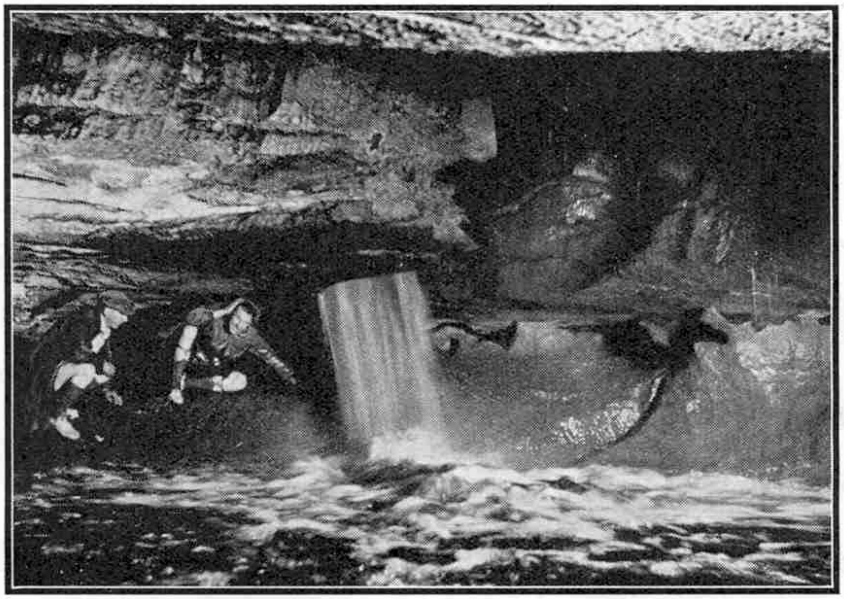
Last midwinter the keepers of this particular beacon were marooned for an entire week, although their tower is connected with land by a solid line of heavy rocks. After the second day their fuel became exhausted, and even though there was an ample supply in a shack 30 ft. away, no man dared brave the gale to walk that short distance. While the cook prepared meals with the aid of a blow torch, others of the watch stood by helplessly, watching the great waves breaking over the tower, smashing windows 30 ft. above the normal level of the sea, and threatening even the light itself.

The keepers of the Los Angeles Lighthouse had a unique experience not long ago. Three times in as many weeks ships crashed within calling distance of the beacon. One night the keeper was jarred from his chair when a rending crash of shearing metal split the night with its message of disaster. He leaped to the window, and there, almost at his feet, was a battleship! Some mix-up of signals or misunderstanding of the course had driven her on the rocks in a storm; yet within a few minutes, due to the good fortune of a glancing blow instead of a head-on collision, she backed away and proceeded to port under her own power. A few days later a merchant steamer, essaying a short-cut into the harbour, smashed into the breakwater, tossing aside rocks weighing 10 tons as though they were so much straw. Again, due to some unexplained good fortune, she escaped relatively undamaged. Ten days or so later five fishing boats seeking shelter in the lee of the rocks from a sudden storm were tossed on the breakwater. All the men were saved.

The light commonly in use in the lighthouses off the Pacific coast consists of two lenses of concentric rings including 60 curved glass prisms. Such a light which costs £11,200, has an official range of 14 miles, but the glow can be seen in the sky on a fair night as far away as 25 miles. In normal circumstances the light alone provides adequate guidance for all ships. But the dread of the mariner is fog. Then fog sirens are resorted to, the captain of the vessel ascertaining his whereabouts by noting the direction and number of the blasts. As a further aid the lighthouses are now equipped with radio beacons.

Professor Boyd Dawkins, aided by a windlass and the navvies working on the Settle-Carlisle railway, accomplished the feat.

If you have no objection to getting your feet wet you can gain some idea of what this pot-hole is like by exploring Long Churn Passage, which leads into the main shaft, and the entrance to which is some 150 yards above Alum Pot. Although no elaborate equipment is necessary to do this, care is essential as there are some small rock-pitches to be negotiated, and one or two rather deep pools to be crossed. I would advise the newcomer to cave-exploring to leave the deep 60-ft. fissure of Long Churn Chimney into the main shaft alone; but by standing on the rocks beside it you can get a wonderful view through the inky darkness to where a shaft of light streams down into the shaft of Alum Pot.



A Pool, known as "Dr. Bannister's Handbasin," in the Alum Pot cave.

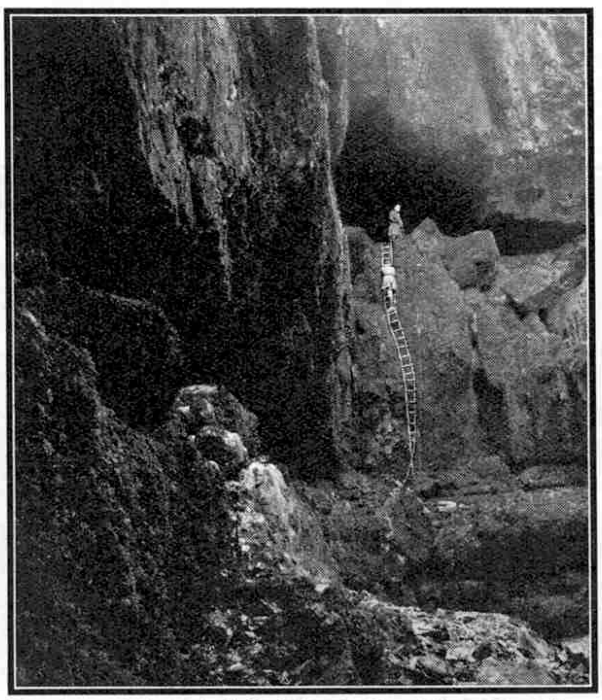
One of the most interesting valleys in Craven from a cave-exploring point of view is the Dale, or Doe, Beck, which rises on the southern slopes of Whernside and flows down between that mountain and Ingleborough, in the direction of Ingleton. This stream has a trick of constantly disappearing into the ground to follow strange subterranean ways, and then coming to the surface again.

About a quarter of a mile below the Hill Inn at Chapel le Dale a sign indicates the way to "Weathercote Cave," which is one of the most interesting features of this valley. A small charge is made to see it, and the proceeds go to St. Dunstan's.

Passing through the gateway into the enclosure, you come to a deep black cavern with the deafening roar of an unseen waterfall adding to the erie fascination of the scene. Some rough-hewn steps lead into the pit, and then, passing under the arch, you come to the second part of the cave where the waterfall, a mad, angry torrent, leaps out of a yawning black hole and plunges over a 77 ft. fall of sheer rock to disappear into a subterranean river again.

From Weathercote you can follow the dry bed of the river upward until eventually you come to the spot where it commences its long underground journey among a series of limestone clints. Still proceed up the dale, and after about a quarter of a mile you reach Gatekirk Cave where the river comes out of a magnificent archway. There are two entrances to this fine looking cave. One is along the riverside and the other a little way to the left. Be careful if you decide to enter by this latter way; after about three yards there is a sudden drop of about 15 ft. to the stream bed.

My last visit to Gatekirk was on a day following heavy rain and the beck was in spate. We managed to scramble along the rocks to the right of the stream for a little way, and then turned off into a subsidiary passage on the same side. After crawling on here for a little way the passage became too low for us to proceed farther, but another opening on our left looked promising. We crawled through and found ourselves in a little chamber, the roof of which contained some lovely stalactites. Out of this a passage led us on to a sandbank beside the main stream again. We stood there for a while gazing at the magnificent sight of the stream pouring out of the graceful arch at the opening of the cave. Upstream all was strife and unrest.



The entrance to the main shaft of Alum Pot from bottom of Long Churn Chimney, by rope ladder descent.

On one side another stream hurled itself out of a side passage with a deafening roar, and as far as could be seen was a succession of fierce rapids. It was impossible for us to venture in that direction that day, so we turned our steps and found that straight behind the sandbank was another passage which led us out into daylight once more.

On the hillside behind the Hill Inn is another cave which can be visited without elaborate equipment. This is Douk Cave, and is a very wet specimen of its kind indeed. About 20 yards above the inn a step stile leads over the wall, and the ensuing track is followed upward for a couple of fields' length. The cave lies in a hollow slightly to the right, and has been walled round to prevent cattle and sheep from falling into what at first sight looks like a disused quarry, but is actually a result of faulting, that is, the slipping, long centuries ago, of the rocks that form the strata of the mountain.

Looking over the wall you will see the entrance to the cave in front of you. A stream pours out of it, and you will have to scramble up beside a waterfall in order to gain access to it. Wading in the stream bed is the only possible means of exploring this cave, and I have known the water be waist high after rainy periods. After about twenty or thirty yards you will be surprised to see daylight streaming in. Here the roof of the cave has tumbled in, and you are at the foot of a deep, narrow rift, with vertical limestone walls on each side. Do not try climbing up these; the hand and footholds are very insecure.

Beyond the rift there are some deep pools to be negotiated. I once visited this cave in company with a friend who had a rooted aversion to walking through any more water than was absolutely necessary, and at this point he decided to proceed straddle-wise above the stream, looking very much like a huge spider. In time, however, the width became too great for his legs, and he was forced to descend into the stream at one of its deepest places!

There are no side passages in this cave, and you can go upstream for a very long way before you need resort to crawling. There are some very fine stalactites to be seen inside Douk.

In the same vicinity you will find the White Scar Caverns, which were only discovered about 10 years ago, and have since been opened up and illuminated so that all can see their beauty. A guide is in attendance to show visitors round, and the whole system is lit up by electric lights. The underground waterfalls extend for nearly a mile in length, and at the far end of the caverns is a newly discovered lake over which parties can be ferried by arrangement.

There are other caves in Craven which can be entered under the supervision of a guide, such as the Stump Cross Caverns on the Grassington-Pateley Bridge road, which contain some of the finest stalactites and stalagmites in the county; and the Ingleborough Cave, near Clapham. These are admirable places for those who do not wish for the thrills and excitement of the explorer, but nevertheless would like to see some of Yorkshire's wonderful underworld.

In conclusion, I would point out that cave exploring is not a pastime for the individual. One or more companions are necessary,

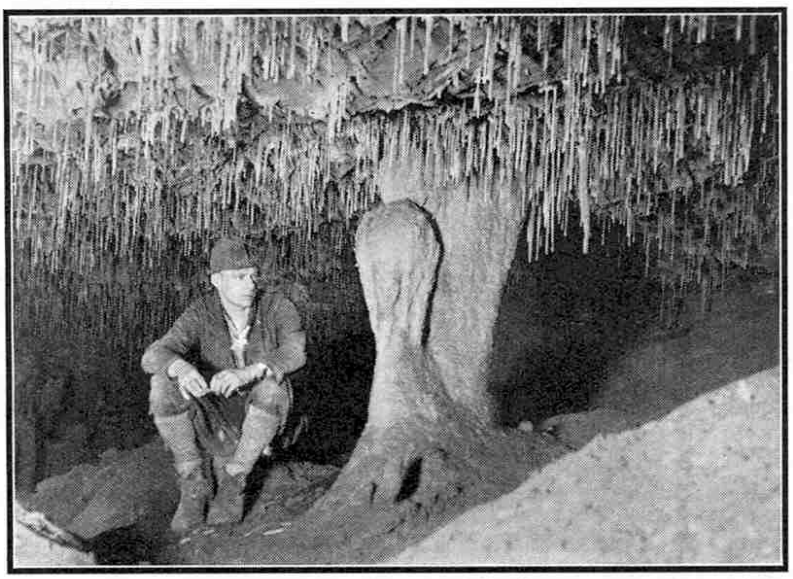
Yorkshire's Underworld

The Fascination of Pot-holes and Caverns

By Sydney Moorhouse

BY reason of its unique subterranean structure, Yorkshire is one of the most interesting counties in England from a geological point of view.

Amongst the limestone hills of Craven will be found immense pot-holes and caverns which have been hollowed out by the action of water on cracks and fissures in the stone. Deep down beneath the surface of the earth are rushing streams, great waterfalls, subterranean lakes and mighty amphi-theatres; and the pastime of speleology, or "pot-holing" as it is more commonly called, which consists of the exploration of these underground ways, is a most fascinating one.

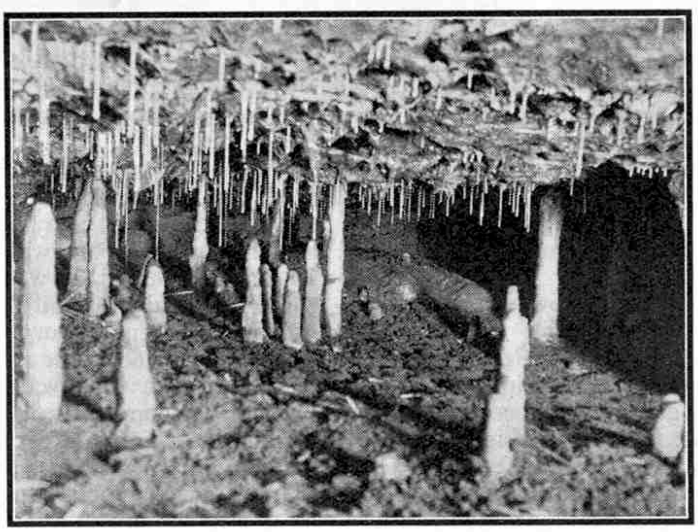


One of the main passages in Gaping Gill, a famous Yorkshire limestone cavern. Photographs to this article are by H. E. Whitaker, Denholme.

Theoretically speaking, a pot-hole is a vertical cave, and is usually connected with systems of caverns and underground watercourses. There is, however, in actual fact very little difference between a pot-hole and a cave, for Goyden Pot, in Nidderdale, is actually a cave, while Lost John's Cave, on Lech Fell, above Dentdale, is really a series of "pots" which require a considerable amount of equipment for their descent.

The largest of the pot-holes is Gaping Gill, which is situated on the slopes of Ingleborough and is some 365 ft. deep. The opening of the main shaft is about 40 ft. across the top, and into it hurtle the waters of the Fell Beck. A Settle man, John Birkbeck, made in 1872 the first recorded attempt to descend the pit, and he succeeded in reaching a ledge 206 ft. below the surface. In 1895 a Frenchman, E. A. Martel, succeeded in getting to the bottom by means of rope ladders. To-day, however, much simpler methods are employed. In order to provide a drier descent the stream is diverted so as to prevent its main force from falling over the lip of the hole, and a winch driven by a petrol engine lowers and lifts a bo'sun's chair in which the pot-holer is carried into the depths.

My first visit to the underworld of Gaping Gill was in the company of the members of one of the leading Yorkshire cave-exploring clubs. Heavy rain had fallen throughout the previous night, so that when we arrived at the top of the pot-hole the stream was pounding down the main shaft and forming an almost impassable barrier. However, floods soon subside in limestone country, and we had not long to wait before we could make the trip. Soon the first man was standing on the wooden gantry which stretched across the mouth of the hole, and was ready to make the descent; and when he had been safely lowered down, my turn came. As the chair passes through the spray of a waterfall, one has to be well attired in waterproofs, and even then is not spared a wetting!



Striking icicle-shaped formations in Gaping Gill.

The journey down the main shaft was a wonderful experience. All I was conscious of at first was a feeling of sliding, yet so rhythmic was the entire movement that I had none of the "sinking feeling" I had anticipated. Light gradually receded and a gloom enclosed me. To my ears came the crashing of falling waters. The rocks on both sides of the cave were streaming with water and luxuriant ferns were growing on the walls.

Thirty feet down a great fall of water issued out of the mountain side, and I looked down to see another huge volume pouring out below. For a moment I thought I was going right through it, but a guiding rope took the chair away from the main fall. On all sides were curtains of water, and I gazed down into rainbow-hued depths.

The walls of the shaft fell away, and I was conscious of nothing but darkness around and a deafening roar of falling water in my ears. Then my feet touched something solid, and I was lifted out of the chair and hurried to some place out of reach of the spray.

I found myself in a great hall, measuring 480 ft. in length, 82 ft. wide at its broadest part, and 110 ft. high, a tremendous cave in which one could put York Minster and still have room to spare. But figures alone can convey no impression of that immense underground hall, with the ceaseless waters crashing through the hole in its roof. A strange blue light comes down the main shaft, and through it the falling waters gleam silver.

Various subterranean passages, worn out by the ceaseless action of the waters, honeycomb the ground, and many of these have been examined and charted for a distance of almost two miles. Many beautiful stalactites and stalagmites are to be found in these passages. Stalactites are icicle-shaped growths of limestone, and have been formed by the evaporation of water, saturated with calcium bicarbonate, dripping from the roof of the cave; the stalagmite grows upward from the floor, and is the result of the stalactite's own deposit. From time to time discussions arise as to the length of time involved in these strange accumulations, but it is impossible to make anything like an accurate estimate of this, as the rate of growth varies from time to time through changes in the amount of lime contained in the water, and the varying direction and volume of the watercourses.

Some two and a half miles to the north-east of Gaping Gill is Alum Pot, which is about 200 ft. deep. An attempt to reach the bottom of this pit was made in 1847, but it was not until 1870 that

The Development of Stainless Steel

Interesting Facts about a Wonderful Alloy

ORDINARY steel such as is used for bridges, ships' plates and frames, structural girders and the like, consists of about 99 per cent. iron, together with .25 per cent. carbon, .15 per cent. silicon, and perhaps .60 per cent. manganese. For certain purposes such steel is not entirely satisfactory, however, and in the search for a more suitable material there have been developed "alloy" steels containing often considerable percentages of nickel, chromium, manganese, tungsten, cobalt, molybdenum and vanadium. One alloy steel has been produced that possesses a tensile strength of more than 100 tons per sq. in.; another, used for crushing machinery, actually becomes harder the more work it has to do; but the greatest metallurgical achievement of the last 25 years is probably the development of stainless steel.

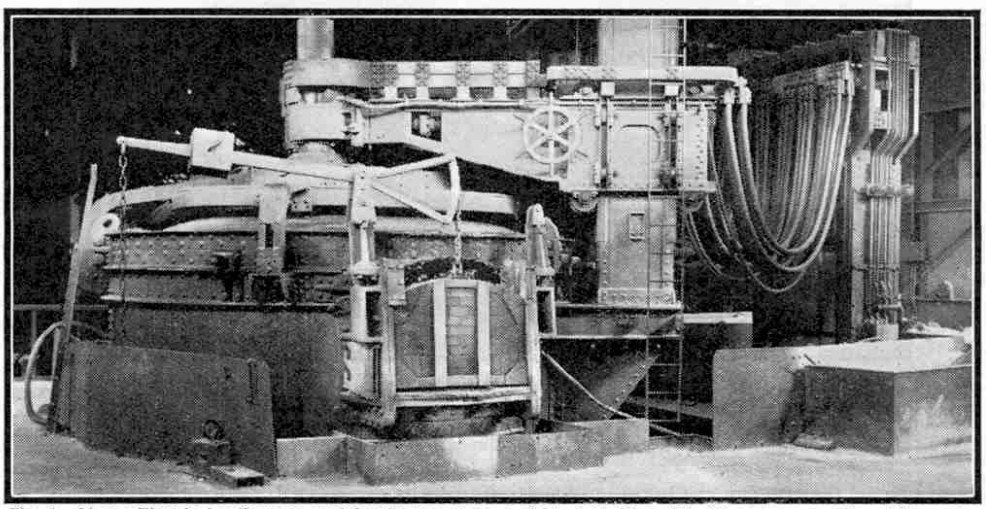


Fig. 1. 30-ton Electric Arc Furnace used for the manufacture of Staybrite Steel. The illustrations to this article are by courtesy of Firth-Vickers Stainless Steels Ltd., Sheffield.

It has been estimated that several million pounds are lost every year simply as the result of the ravages of rust and corrosion. We are all familiar with the sight of rusted knives, rusty railway lines, and rust on ships' plating; and there are many cases in the chemical industries and elsewhere that we do not usually see, where tanks, pipes and valves are pitted and actually eaten away by the corrosive attack of acids. By the suitable addition of alloys to the steel its inherent properties are fundamentally altered, and according to the alloy additions it contains it is made proof against rust, sea-water and even acids, including strong nitric acid and boiling acetic acid.

Chromium and nickel are the principal alloy elements used. Chromium occurs naturally as the oxide found in the earth in combination with iron oxide, in a mineral called chromite. It is mined in New Caledonia, Rhodesia, Turkey, Russia, California, India and one or two other places; and an iron-chromium alloy known as ferro-chromium is obtained by reducing the ore with silicon and carbon in electric furnaces. Nickel occurs mainly as the sulphide, in Ontario, Canada, and is reduced to the pure metal either by smelting or by a complicated chemical procedure known as the Carbonyl process.

Both chromium and nickel are found in sufficient quantities in the Earth's crust; but the cost of mining the ores, reducing the metals, and then making and working the alloy steel, is such that it is not economical to replace all ordinary steel with the stainless variety. Rustless ships, for example, remain a dream of the future. Nevertheless, rustless and acid-resisting steels are used to-day in applications as far apart as cutlery and surgical instruments, motor boat propellers and yacht fittings, domestic hollow ware and huge pieces of chemical plant weighing several tons.

Let us now consider the effect of these various alloy additions in modifying the properties of ordinary steel and the origin of stainless steel itself. It has been said, not wholly without foundation, that stainless steel was first discovered in a Sheffield steelworks laboratory by accident. A steel containing chromium had been made and, after testing, a piece was thrown away. It was then noticed that this steel had not rusted like the other pieces of steel on the heap; and subsequent research showed that steel containing from 12 to 14 per cent. of the metal chromium was immune from ordinary rusting when exposed to wind, rain, ice or snow, and was free also from certain other types of corrosion.

This was a great discovery, and 12 to 14 per cent. chromium stainless steel is now used in nearly every household in the form of stainless knives. It is employed also by surgeons and dentists for surgical and dental instruments, and for ordinary pocket knives. In engineering it is used for steam valve seats, because it avoids the pitting caused in ordinary steel by high pressure steam; and it is used for golf ball moulding dies and other dies for rubber and plastics because it retains its high polish.

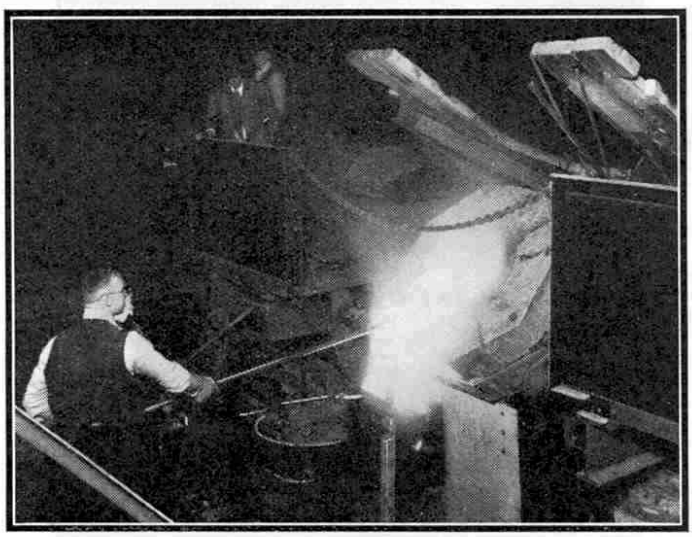


Fig. 2. Tapping a one-ton High Frequency Furnace.

The steel can be hardened to a razor temper, and is actually used for razor blades; but is more often put into service with a tensile strength of 40 to 50 tons per sq. in., that is, a strength equal to that of the usual alloy steels used for such parts as motor car front axles and railway locomotive connecting rods.

If the chromium addition is raised from 12 to 14 per cent. to as high as 18 per cent., and 2 per cent. of nickel is also added, the properties of the steel are considerably modified, and a special type of stainless steel, with a limited but valuable field of application, is produced. Its tensile strength is a little higher than that of ordinary 12 to 14 per cent. chromium rustless steel, and its corrosion-resisting properties also are improved. It is used mainly for various machined fittings on aeroplanes.

Steel for these purposes is supplied under the Air Ministry specification S.80, and consequently this alloy containing 18 per cent. of chromium and 2 per cent. of nickel is frequently called "S.80" steel. It is used for many purposes other than for aircraft, however. Mr. Scott-Paine, in his record-breaking run at Venice, when his motor-boat *"Miss Britain"* touched 111 miles an hour, used a

propeller shaft made of S.80 steel; and as an example of a very different kind of application, it is used for spindles in ice-cream making machines.

We now come to the latest and most remarkable type of stainless steel. This is the type containing 18 per cent. of chromium and 8 per cent. of nickel, which is familiar under its more usual name of "Staybrite." As regards mechanical properties, its strength is a little below that of ordinary alloy steel, but its ductility is very much greater. If a bar of ordinary steel of similar tensile strength is pulled until it reaches breaking point, it will have stretched about 25 per cent. "Staybrite" steel, however, will stretch 60 or even 70 per cent. of its original length before fracture occurs. This gives some idea of its amazing ductility, but it is not on account of its mechanical properties, but for its corrosion-resisting properties, that this steel is so valuable.

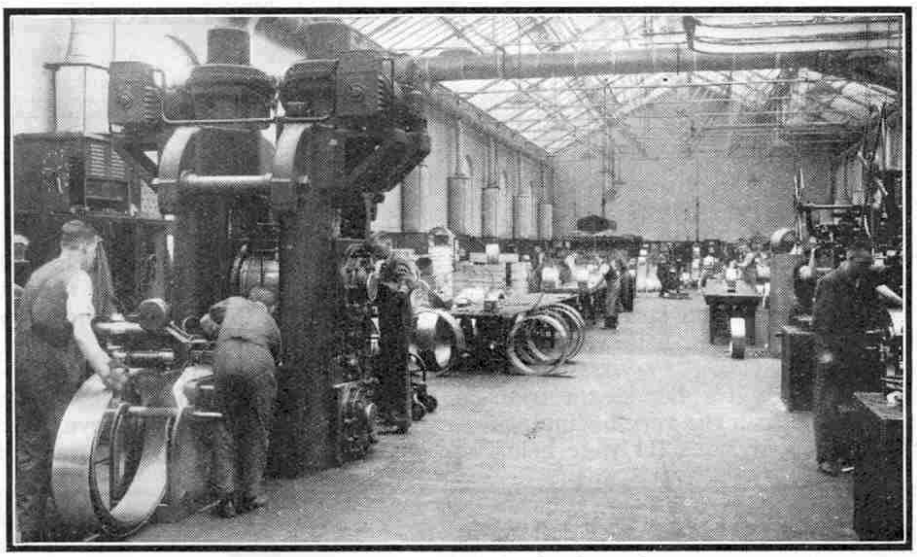


Fig. 3. Rolling stainless steel strip for aircraft manufacture.

Straight chromium rustless steel resists ordinary weathering and certain other corrosive media, and S.80 steel resists sea-water as well; but "Staybrite" steel goes still further, and is acid-resisting. This means that it can be used in contact with most mineral and organic acids, even at high concentrations and high temperatures; as well as with many other corrosive agents that would attack and ultimately destroy ordinary steel. Let us consider for a moment what this means in practice.

In the chemical industries the manufacture and handling of nitric acid and nitrates is an important matter. Even strong nitric acid can be handled by "Staybrite" steel, and storage tanks, transport tanks, pipes, pump parts, valve parts and other details are now made in this material.

In the past, dye-vats used to be made of wood. This was satisfactory up to a point, but had the obvious disadvantage that when the vat was emptied of one coloured dye and another was put in, traces of the first remained soaked in the wood and contaminated the second. Dye-vats, winches, rollers, steaming cans, pumps, valves, and all the other paraphernalia of the dye-works are now made from "Staybrite" steel.

Every day thousands of gallons of milk are carried to London by train or road tankers. These tankers are made from "Staybrite" steel and ensure absolute cleanliness.

One could go on for a long time discussing the many uses of this wonderful new steel. Many readers will have seen it in shop-fronts, lift gates, furniture in modern houses, clock faces, and camera fittings. They will have sat down to a meal prepared in "Staybrite"-fitted restaurant kitchens, cooked in stainless steel pans and eaten with stainless steel knives and forks. They will have seen it in the radiators, hub-caps, and other bright parts of many motor cars, and will have seen stainless steel aircraft in the air above their heads.

The application of stainless steel to aircraft in recent years is one of great importance. For many years spruce has been used for the airframe, and has given splendid results; but there is an obvious risk in using a fibrous material such as wood. No matter how carefully it is selected, there is an ever-present danger of premature failure from shakes and other imperfections of the grain. The use of ordinary steel and the light aluminium alloys overcomes this difficulty, but opens up a new set of dangers due to corrosion. When the fabric covering is stretched over wings and fuselage, the pilot wants to be certain that rust and corrosion have not weakened the structure where it is not seen; his life depends upon it. Only by the use of stainless steel can absolute certainty be attained. The 18 per cent. chromium, 8 per cent. nickel steel is produced in several forms specially for aircraft.

It will be of interest now to describe very briefly how stainless steel is made.

Reference has already been made to the occurrence of chromium and nickel as minerals in the earth and how they are reduced to the alloy, ferro-chromium, and to metallic nickel respectively. These two alloy materials and ordinary steel scrap form the basis of the process. Steel scrap, that is to say odd-shaped and comparatively worthless pieces of steel obtained as scrap products in other parts of the steelworks, is charged through the door of an electric arc furnace. The big 30-ton furnace used by Firth-Vickers Stainless Steels Ltd., is illustrated in Fig. 1. Sticking through the roof are three carbon electrodes—only one can be seen but there are two more behind it—and one phase of a three-phase electric power supply is connected to each electrode. The electrodes are then lowered until an arc is struck between them and the steel on the bottom of the furnace.

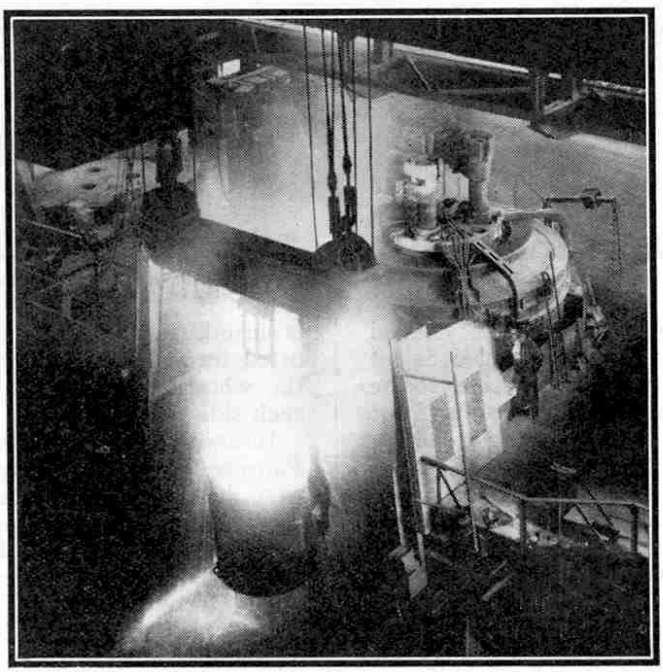


Fig. 4. Stainless Steel being poured from the furnace into a ladle hung from a crane.

If we take an ordinary flash-lamp battery, hold a piece of carbon rod against each terminal, and touch them almost together, we shall obtain a very small arc. This is the principle on which the furnace works, only on a much larger scale.

Each electrode takes about 15,000 amperes, and the whole furnace consumes something in the order of 6,000 kilowatts, or just 100,000 times as much power as a bright electric lamp. The intense heat of the arc melts the steel in two or three hours. Ferro-chromium and nickel are then put into the furnace, together with some ferro-silicon and ferro-manganese, in quantities calculated to give the exact analysis; and the slag covering over the metal is adjusted in composition to refine the steel. After a refining period, during which time the steel is degasified and deoxidised, samples are taken out of the furnace, and when these have shown the condition of the steel to be right, the whole furnace is tilted forward and the steel is poured out into a ladle suspended from a crane above (Fig. 4). The molten metal is then poured into moulds, forming lumps about 1 ft. square by 4 ft. long, called "ingots." Fig. 2 shows the steel being poured out of a smaller furnace of a different type.

The ingots are then pulled out of the moulds and examined. Next they are heated to a good red heat and rolled down to bars or slabs, and later still further to rods, sheets or strips.

This concludes our brief and necessarily incomplete account of the development of stainless steels from ordinary steels, and their present-day application and production.

Railway Bridges

Notes on Familiar Types

By C. H. Hewison (Locomotive Running Department, Walton-on-the-Hill, L.N.E.R.)

THERE are, up and down the lines, numerous features not always observed by those who use the railways, and a little knowledge about some of the constructional works will probably bring new interest to many of our readers in details they have not previously noticed. The bridges are the most important structures on a railway, for without them railways could not exist at all.

The following remarks about bridges are intended to be quite general. No two bridges are ever alike, but it will be found that most bridges more or less follow the principles here laid out.

All small bridges carrying the railway over minor roads, streams, etc., are usually of the stone arch type (Fig. 1). They are very strong and durable, but stone is an expensive material and the bridge is costly to erect, elaborate temporary staging being required to build the arch on; in these days of economy, therefore, stone bridges are seldom built. Moreover, when the railway crosses a road obliquely, that is, not quite at right angles, a skew arch has to be introduced which, owing to the distances from the centre of the arch to the skewbacks being greater on one side than the other, has the courses of masonry at an angle to, instead of parallel to, them. Each stone for the skew arch has to be very carefully and accurately cut and although brick is sometimes substituted, skew arches are always very expensive.

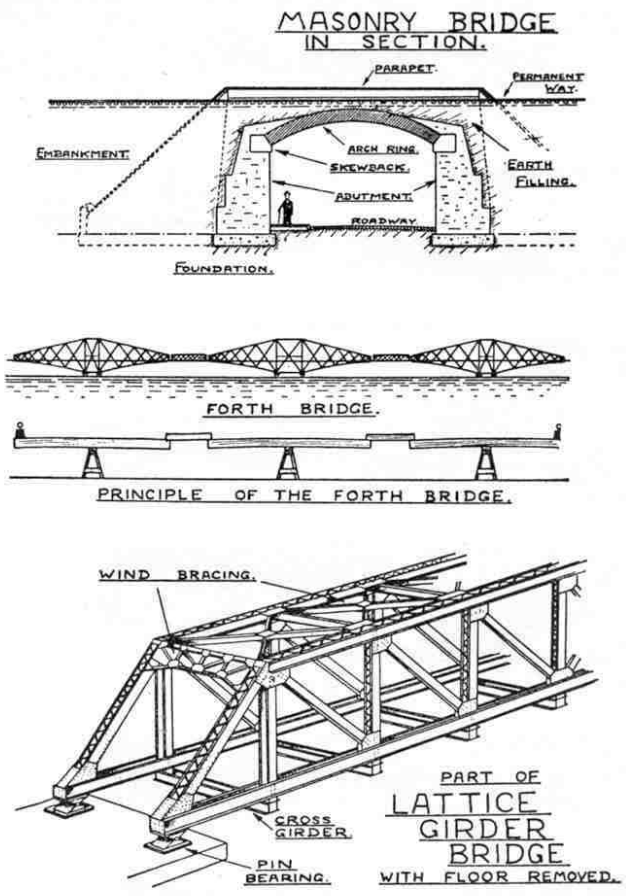


Fig. 1.

Modern bridges of moderate size crossing roads, other railways, etc., are usually of the plate girder type. The chief parts of a plate girder bridge, of which a typical example is illustrated (Fig. 2), are the two main girders, built up of steel plates riveted together. The upright centre portion of the girder is called the web and the horizontal parts at the top and bottom of the web are the flanges, secured by rivets to L-shaped steel bars called angles which in turn are riveted to the web.

If a piece of wood about an inch square in section is placed across two bricks, stood on until it breaks and then the fractures examined, it will be noticed that the portion of the material which was uppermost has the appearance of having been crushed, while the lower part will be jagged as if it had been torn apart. What actually takes place in any beam when a load is put on it is that the upper part suffers a compressive force and the lower part is put into tension. Now the purpose of the flanges of a girder is to withstand these forces, and they are made sufficiently thick, being built up with three or four steel plates, so that when the heaviest load the bridge will ever be likely to have to carry is imposed, each square inch of the flanges' sections will not have more than about 5 tons per sq. in. tension or compression. In early days of railways cast iron girders were often used for small bridges, and these have their bottom flanges much bigger than the top ones, because cast iron is very much weaker in tension than in compression. As the bending moment is greatest towards the centre of a girder the flanges are usually made thicker at the middle than at the ends.

The most economical design is obtained by making the girder equal in depth to about one tenth of the span. The web, being usually rather thin in proportion to its height, has to be stiffened to prevent it from buckling or bending over sideways, and this is done by fitting some steel angles or "gusset" plates vertically on the sides, a few feet apart, together with a stout plate at each end of the girder.

Between the two main girders of the bridge are stretched the cross girders, fastened with angles to the main girders' webs and resting on the inner edges of their bottom flanges. They are usually spaced about 6 ft. apart. Between the cross girders are placed the railbearers or stringers, so spaced as to be directly under the rails of the permanent way; they are usually secured so that their upper flanges may be level with the tops of the cross-girders, permitting plates to be laid on the framework thus formed. This floor is covered with a bed of asphalt about an inch and a half thick over which the ballast is spread and the permanent way laid in the usual way. As an alternative to the cross-girder system, trough floors are sometimes laid, especially in bridges carrying a single line of railway.

Plate girders are rarely used for bridges beyond a hundred feet span owing to the excessive weight and amount of material required. For larger bridges over rivers or very wide streets lattice girders are introduced. A large variety of types of lattice girder bridges exists, constructed to all sizes; one of the largest in the British Isles is on the L.N.E.R. main line at Newark, over the River Trent. The chief types of lattice girder are illustrated (Figs. 1 and 2), and in modern bridge construction of moderate size, the N-girder and the Warren girder are probably the most used. The general principle of the bridge is the same as the plate girder type; two main girders carrying cross-girders which in turn support the floor and the track. As a rule the cross-girders are level with the bottom of the main girders, but, where levels permit, they are sometimes carried on the top, forming a "deck" bridge, a better form of construction which can be made much stiffer and is less affected by wind pressure. The lattice girder consists of an upper and lower boom to take the compressive and tensile stresses respectively, and these are kept in position by ties and struts instead of a web. A tie, it should be explained, is a member in tension while struts are designed to resist compression. In an ordinary N or Linville girder which may have sloping or vertical ends, the vertical members are always in compression and the sloping members, except the end ones, if sloping ends are included, are in tension. This is true when the load is centrally imposed, but on a bridge the load may be anywhere and when near one end the centre sloping members are liable to be put into compression; as they are not designed for this, two more ties sloping in the opposite direction are included to provide for uneven loading.

For all sorts of steel constructional work, not only bridges, but steel frames for buildings, big roofs, electric cable pylons and a hundred other structures, standardised commercial sections, of which the principal are the I-beam, or joist, the channel or U-section, the angle or L-section, and the tee, are available. These sections are made in lengths to a variety of sizes laid down by the British Engineering Standards Committee and are of mild steel. Flat bars are also available and these sections are used together with plates for every form of steelwork.

The booms of lattice girders are usually built of two, three or four plates with angles in the corners to form a box-like member.

The upper boom being in compression has to be very solid because a member in compression must, in addition to being big enough to withstand the direct load, be stiff enough to avoid any risk of buckling or bending out sideways. The longer the member, the greater this tendency, and the Whipple or double-N girder has the advantage that the segments of the upper boom are very short. If there are only two plates in the upper chord, it is rendered stiff by a system of cross bracing lacing them together, for which short flat bars are used. The bottom boom has only to resist tension and is usually constructed of two parallel plates, or three plates to form a channel, but there is no need for any cross bracing unless the ends of the girder are finished with vertical posts when the plates are usually laced together in order to resist longitudinal compression that might be caused by a train crossing the bridge with brakes hard on.

The upright vertical members are built up of "channels" or "joists" and being in compression must, like the upper boom members, be stout enough to avoid risk of buckling; the sloping members in tension generally consist of two strong plates alone. The top and bottom booms are invariably built up with a pair of plates so that the ties and struts can pass and be secured between them; a brief examination of any lattice girder bridge will show how this is done. The vertical members are carried right through the bottom boom in most bridges, the cross girders carrying the floor of the bridge being riveted to the extensions. The cross girders must always be fastened to the bottom boom at places where the ties and struts intersect, called panel points; any application of the load between the panel points causes bending of the boom segments, which is undesirable.

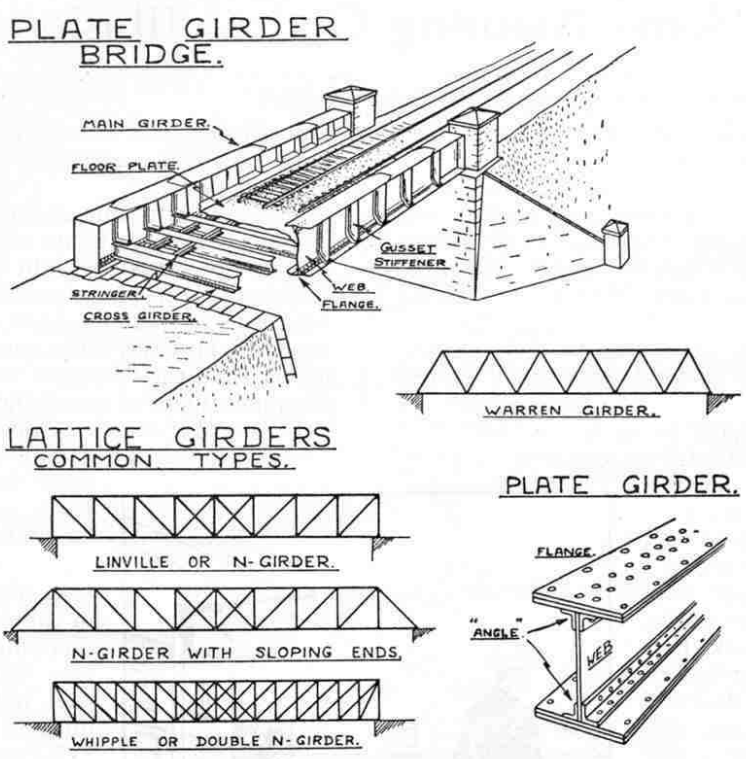


Fig. 2.

The two girders are usually braced with cross frameworks at the top, carried down as far as the railway loading gauge will permit. This stiffens the bridge against the force of side winds, an important factor in the case of large girders.

Girders that are more than about 80 ft. in length have to be provided with pin and roller bearings to allow of free deflection and of expansion and contraction owing to changes of temperature. Each end of the girder rests and is secured on to a strong casting which in turn beds firmly on to a horizontal steel pin, about 30 in. long and 7 or 8 in. in diameter; the pin in turn rests in a suitable socket in a cast steel bedplate, this being secured to the abutment. The deflection of a bridge when a train is crossing is only slight, but the pins permit it to take place without any undue strain being imposed at the ends of the girders. The girders are as a rule made very slightly curved, being an inch or so higher at the centre than at the ends, so that the bridge will be deflected into the true form rather than out of it. At one end of the bridge the bedplate rests on rollers, instead of being fastened down, to allow for expansion in warm weather. The amount of expansion is very slight; it could hardly be measured with an ordinary footrule, but serious strains and probable damage would result to the bridge were it not provided for. The casting which carries the bearing pin, instead of being secured, rests on a set of rollers, six to eight in number, and about 6 in. in diameter, resting in turn on a lower casting resting on the abutment. It is not always easy to see the bearings of a bridge as they are frequently below the ground level, but if the abutment is not too high they can sometimes be observed from below.

For very large spans bridges of special design are built. Most of the world's largest bridges are to be found in other countries, particularly in the U.S.A., for Great Britain is without any very large rivers and valleys to be crossed.

The Forth Bridge (Fig. 1) is the only really big bridge in the British Isles. This bridge, as every one knows, is of the cantilever type and each span consists of a pair of protecting arms reaching towards each other, the gap between their ends being bridged by means of an independent suspended girder. The weight of all these is balanced by projecting arms reaching shorewards and anchored down.

Viaducts consist of a series of short spans, sometimes 20 or 30 in number, carrying the railway over a wide valley. There are numerous examples all over the L.N.E.R. system, at Welwyn, Dinting and Berwick-on-Tweed to mention but three. They are mostly of the stone or brick arch type, but sometimes consist of girders resting on masonry piers. In the early days of the Great Western Railway timber viaducts were largely introduced, and some of them were in use up to a few years ago.

Where a railway bridge crosses a navigated river, an opening span must be provided to permit of the passage of ships, unless the bridge is carried at a great height above the water with long approaching embankments, as on the Cheshire Lines Committee, where the railway crosses the Manchester Ship Canal. Here again a great variety of types is to be found, but the swing bridge is the most common and a well-known example is the Hawarden Bridge, which carries the L.N.E.R. line from Chester to Wrexham over the River Dee. The whole structure is pivoted at or near the centre, so that it revolves in a horizontal circle; machinery, usually hydraulic, or electric in more modern cases, is provided for the opening of the span, although bridges that are not required to be opened very often are sometimes operated by hand winches, suitably geared. To reduce the effort required the weight of the span is carried by a large number of radially set rollers, running on a circular track, the centre pivot being only to keep the bridge in position. Swing bridges have several disadvantages however. The whole movable span is carried by one foundation, and should this move or sink in the slightest degree the bridge would be unable to function properly; the foundation is usually placed almost in the centre of the river, so that the pier it carries supporting the bridge is in constant danger of damage from collisions with ships, while a strong wind will often interfere with the opening and closing of the span.

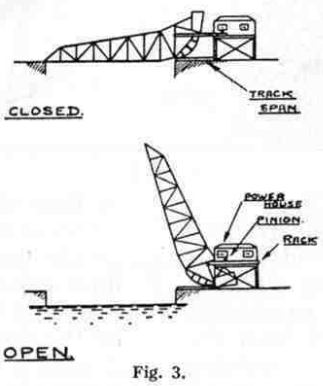


Fig. 3.

The most modern type of opening bridge is the rolling lift type illustrated in Fig. 3. It has none of the swing bridge's failings. The rolling lift bridge, of which the L.N.E.R. has an excellent example at Keadby, has one end of each main girder curved up with a balance weight above so that the whole bridge can be rolled back, rising to a vertical position as it does so, like a drawbridge. The power house is stationed at the end, usually on a gantry, over the railway, and operates a pair of large racks coupled to the girders of the bridge, and when this is wound to and fro, the bridge is raised or lowered as required. The segmental, or curved, portions of the girders have to be very stoutly built as they have the whole weight of the bridge to carry when it is open. The paths on which the girders roll are called the track spans, and these too, must be very substantial.

The maintenance of the company's bridges is very important work and is attended to very thoroughly. Every few years all the steelwork is scraped, any parts that have weathered thin replaced, and the joints well dressed with red lead, the whole structure being finally carefully painted. Grey or dull red are the usual colours, for unfortunately paint of the most attractive shades is usually expensive.

We are indebted to the courtesy of the Editor of the *"London and North Eastern Railway Magazine"* for permission to reproduce this article and the accompanying diagrams.

Domestic Gadgets in Meccano

A Few Hints to Model-Builders

USES for Meccano parts are not by any means confined to model-building, and the keen Meccano boy uses his Outfit to advantage for making many little fittings for his "den." All kinds of useful gadgets can be made to serve really practical purposes for improving comfort and convenience. The individual adaptability of Meccano parts makes them also particularly suitable for numerous odd purposes about the house, and they are specially useful in an emergency. With a little ingenuity broken articles can be repaired, or new ones improvised, by the use of appropriate parts, and often a sound repair can be carried out in this way to effect a big saving in the cost of a new article.

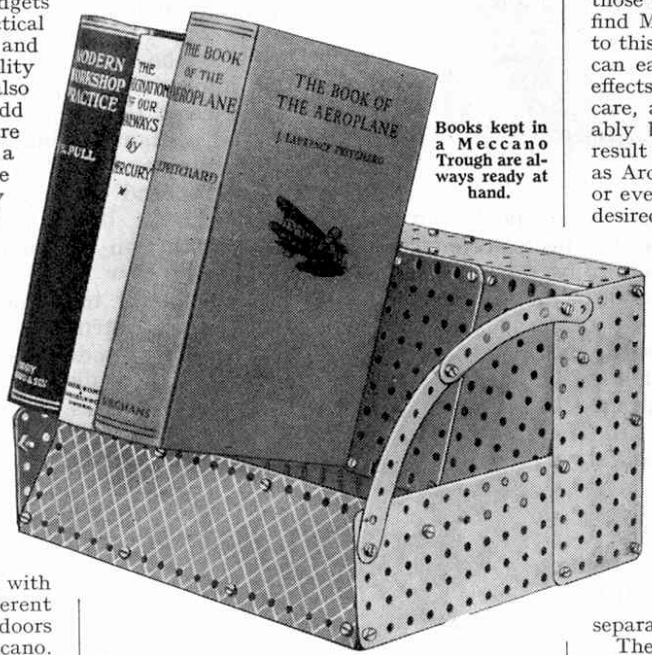
Meccano is useful to the woodworker and can be the means of saving much time in making small parts and fittings. For instance Hinges can be used for doors on small cabinets, and if necessary corners can be strengthened by Angle Brackets, Corner Brackets or Architraves. In addition to their uses for cabinets and box making, these parts can be applied in a large number of cases where it is desired to strengthen a right-angle. Angle Girders, too, can be used with success for similar purposes. Many different shapes and sizes of knobs for small doors and drawers can be made in Meccano. Parts that suggest themselves for this purpose are ½" and 1" fast Pulleys, Handrail Supports, and perhaps Collars, according to the special requirements. To secure these parts Meccano Woodscrews (No. 68) can be used, or they can be fixed in place by ½" or ¾" Bolts or 1" Screwed Rods. To use these Bolts in place of Wood Screws it is necessary to drill the wood to which they are to be fixed, and a 5/32" drill should be used. Washers should be placed beneath all nuts and the heads of Bolts that are tightened against wood, to prevent them from sinking in.

Some constructors hesitate to use parts from their Outfit for purposes such as these, as owing to the depleted range of parts the possibilities of their Outfits are reduced. However, the practical applications of the parts generally justify their use and, of course, new parts can be added to the Outfit to make it complete again. In some cases the parts are required only temporarily and can be replaced in the Outfit when they have served their purpose. It is often worth while buying new parts specially for a particular job.

Book Trough

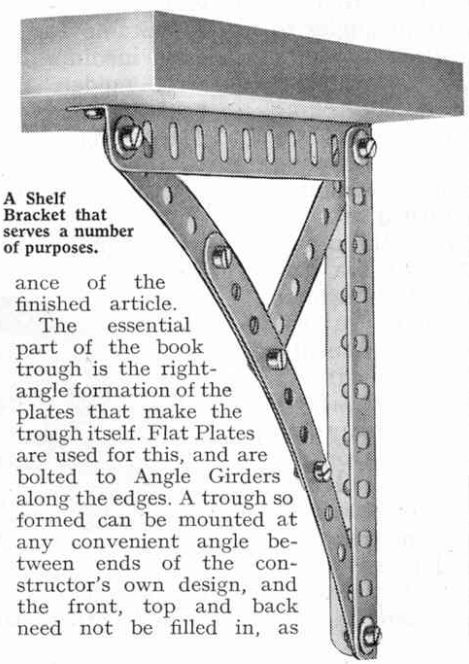
"Bookworms" who divide their interest between several books at once should build up a suitable rack to hold them when not in use. This avoids leaving the books in odd corners, and they can always be found immediately when required. The small book trough shown on this page is both attractive and useful.

The size of the trough will be governed by the average size of the books and the number that will be kept in it. The model illustrated is suitable for small and medium sized books and will accommodate up to half a dozen. It is 9½" long and is made up chiefly of Angle Girders and Plates. Such a subject as this can be built in various different ways according to the ideas of the constructor, and some very attractive results can be obtained. In building the model, the placing of the different coloured parts should be considered so that the colour combinations enhance the appearance of the finished article.



Books kept in a Meccano Trough are always ready at hand.

The essential part of the book trough is the right-angle formation of the plates that make the trough itself. Flat Plates are used for this, and are bolted to Angle Girders along the edges. A trough so formed can be mounted at any convenient angle between ends of the constructor's own design, and the front, top and back need not be filled in, as in the model illustrated.



A Shelf Bracket that serves a number of purposes.

A subject such as this offers much scope for artistic work. It can be built in an ornate style or of extreme simplicity, and those who favour ultra-modern designs will find Meccano parts particularly applicable to this sort of work. Any geometrical shape can easily be formed, but to get the best effects the parts should be chosen with care, and several arrangements will probably be tried before the most attractive result is obtained. For this work, parts such as Architraves, Trunnions, Girder Frames, or even Windmill Sails, often give just the desired effect, and some very pleasing designs can be produced. If the book trough is to be placed on a polished table it is advisable to stick small pieces of rubber or felt at the corners to prevent scratching.

Book Ends

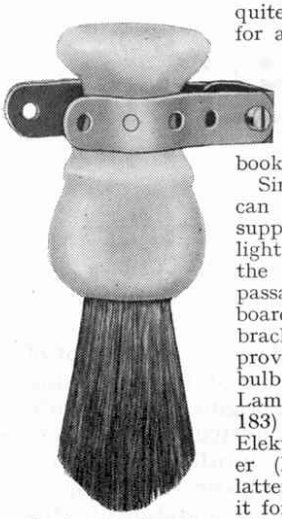
Book troughs such as the one illustrated are generally used for holding a few books only, although they can if necessary be made any size. However, it is often more convenient and more economical to use a pair of book ends for holding a long row of books upright on a shelf or table. Any number of books can be supported in this way by moving the book ends closer together or separating them according to requirements.

The simplest book ends are made by forming a right-angle of Plates. One arm of the angle is placed under the end books of the row so that the other arm is vertical and holds the books upright. Ends made in this way take up little room in use and are not costly to build.

More elaborate book ends can be made by adding ornamental work on the outside of the vertical Plates. Part of a model can be built up and made to project from the Plate, and a novel way of treating the subject is to build say a motor car or aeroplane in two sections so that the front of the model projects from one book end and the rear from the other. This gives the effect of the car or aeroplane driving or flying through the books! Cranes, locomotives, ships, etc., can all be reproduced in this form, or the ends may be of purely artistic design.

Shelf Bracket

This is a particularly useful device for fitting up a temporary shelf and can be used in other cases where rigid bracing is required for a right-angle corner. The great advantage in the use of Meccano for this purpose is that brackets of any size can be built with ease. The one illustrated is made up of two 5½" Angle Girders braced by 5½" Curved Strips and a 3½" Strip. Shelves of any length can be made by using two or more of these brackets for supporting a plank of the required dimensions. If great strength is necessary the supporting brackets can be made more rigid by duplicating the Angle Girders and using Angle Girders in place of the Curved Strips, but the construction shown will be found



Shaving Brushes last longer when hung by the handle.

quite strong enough for all ordinary purposes. Several shelves can be set up in this manner to make a set of book shelves.

Similar brackets can be made for supporting electric lights for fixing to the wall in dark passages and cupboards, etc. Each bracket would be provided with a small bulb screwed into a Lamp Holder (No. 183) or into the Elektron Lamp Holder (No. 1534). The latter is preferable as it forms also a small reflector. If a Transformer is available for lighting the lamps this can be accommodated in any suitable position and wired up to the lamps, which would be connected in series with a switch. To guard against the possibility of damage caused by a short circuit a fuse unit should be plugged into the Transformer. A Meccano switch can be built up, or the Elektron Switch (No. 1572) can be used.

Dry batteries serve as an alternative to the Transformer, and can be incorporated on the wall bracket itself, in which case the switch also would be fitted to it, making an entirely self-contained lamp.

Reading Lamp

A novel form of lamp for clipping to a book for illuminating the pages is illustrated. With a dry battery mounted in position there are no wires to restrict the movement of the book so that it can be taken wherever required. Those who take their books to bed for reading after "lights out" will find obvious advantages in this form of light.

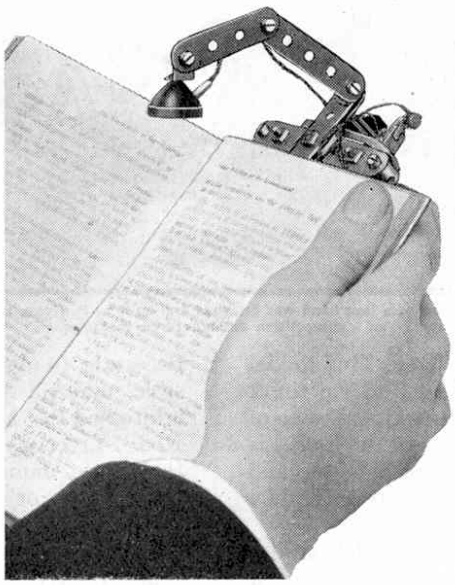
A standard 4½-volt flashlamp battery is used in this device, which is clipped to the back of the book by means of two 5½" Strips. The Strips are spaced apart by two Washers on each of two bolts, one of which carries an Angle Bracket and the other a 3½" Strip. The 3½" Strip is bolted at right angles to the clip and a Threaded Boss is secured at each end. The battery is placed between the Threaded Bosses and another 3½" Strip is clamped against the battery to hold it in position. The second Strip is held by two ¾" Bolts screwed into the Threaded Bosses and provided with Washers that are secured by nuts to serve as knobs. To make allowance for the bolt head at the centre of the one 3½" Strip, two additional bolts are secured on the Strip for the battery to rest against. A lantern from the Meccano Lighting Set is attached by its special bracket to a 2" Strip fixed to the Angle Bracket on the clip by a 2½" Strip. The Angle Brackets and Strips are joined together by locknutted bolts secured fairly tightly so that the parts remain in any set position. The locknuts prevent the pivots from working loose.

A pea lamp is used for illumination and is inserted in the slot in the lantern, which is provided with the clear celluloid disc. To avoid the flex from the lamp getting in the way it is wound several times round the battery and then attached to the terminals of the special battery clips supplied with the Lighting Set.

Watch Stand

Many practical uses can be found for the Meccano Lighting Set, and another useful application for the lanterns is shown in the Watch Stand illustrated. This simple model can be built with Outfit A with the addition of the Lighting Set, and its usefulness will be readily appreciated, especially during the dark nights and mornings of the winter. If placed within easy reach of the bedside the watch can be lit up to show the time at any hour.

Of course, it is not essential for the stand to be built up exactly as shown; in fact, most constructors will have their own ideas on how it should be made. The chief essential is the lantern, which should be carefully placed to light up the watch dial without casting a reflection in the glass. A simple push button switch is all that is necessary for the lamp, and can be devised from a Strip attached to a Plate by a 6 B.A. Bolt and insulated by Bushes and Washers. Another 6 B.A. Bolt should be fixed to the Plate directly beneath the Strip so that by depressing the Strip it



Battery and lamp are clipped on the book for lighting the pages.

touches the head of this Bolt and completes the circuit for the lamp. If an Elektron Outfit is available the Switch from this can be brought into commission as it is excellent for the purpose.

Cycle Rear Lamp

By fitting the coloured discs in the lanterns several other uses can be found for them. For instance, with the red disc in a lantern a neat rear lamp for a bicycle can be made; or a stop light to show when the brakes are applied, thus warning following traffic to slow down. There should be no difficulty in fitting the lantern to the bicycle. It may be attached to one of the special brackets of the Lighting Set and bolted to a clip made of Strips for fitting to the seat stays of the bicycle, or the bracket may be attached direct to the bicycle carrier or some other convenient part.

For operating a stop light a clip can be made of Strips and attached to the handlebars so that as soon as the brake levers are moved to operate the brakes the electric circuit is completed for the lamp. The battery can be carried in the saddle bag, or a special box may be made and clipped to the frame to hold it.

Shaving Brush Clip

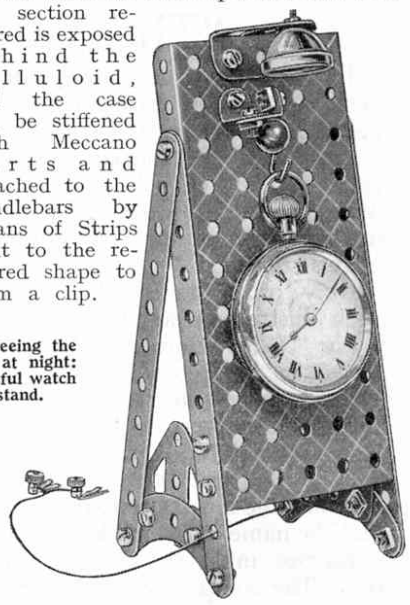
The simple clip shown at the head of this page helps to prolong the life of a shaving brush. After use most brushes are put away to dry standing upright on their handles; but instead of drying off, the water runs down the bristles to the head of the brush, eventually finding its way into the handle. When a brush reaches this stage it is perpetually damp. To avoid such a condition, and to keep the brush always fresh, it should be hung with the bristles downward, giving them a chance to dry off. To make the clip illustrated, two 2½" Strips are slightly bent and fixed to a Double Bracket that is screwed to the wall.

To carry the idea further, a complete shaving stand can be made. This would support a mirror on adjustable mountings, with a clip for the brush and a place for the razor, and also for the hot water container. Yet another addition to increase the utility of the stand would be a small clip or hook for a tooth brush. Such a stand could be built up on a box-like base provided with a hinged front to make a convenient receptacle for tooth paste, shaving cream and razor, etc.

Accessories for Cyclists

Many uses for Meccano parts will occur to cyclists. A carrier can be made of Angle Girders and Strips, or an extra light one from Axle Rods and Couplings, and in the summer these carriers may be adapted for supporting pannier bags when camping gear is to be carried. A light frame built of Axle Rods and attached to clips at the top of the seat stays makes a useful support for a large touring bag suspended behind the saddle. Riders who like to have many gadgets on their machines can make a watch clip for fixing to the handlebars, and add a refinement by fitting a lantern for illuminating it at night. Those with good watches will be well advised to obtain cheap ones for this purpose.

Although many cyclists do little riding during the winter there are others who regularly cover long distances regardless of the weather. When on strange roads on a wet day it is awkward to refer to the map without its becoming soaked with rain, but this difficulty can be overcome by making a waterproof case for it and using clear celluloid for the front. The map is folded so that the section required is exposed behind the celluloid, and the case can be stiffened with Meccano parts and attached to the handlebars by means of Strips bent to the required shape to form a clip.



For seeing the time at night: a useful watch stand.