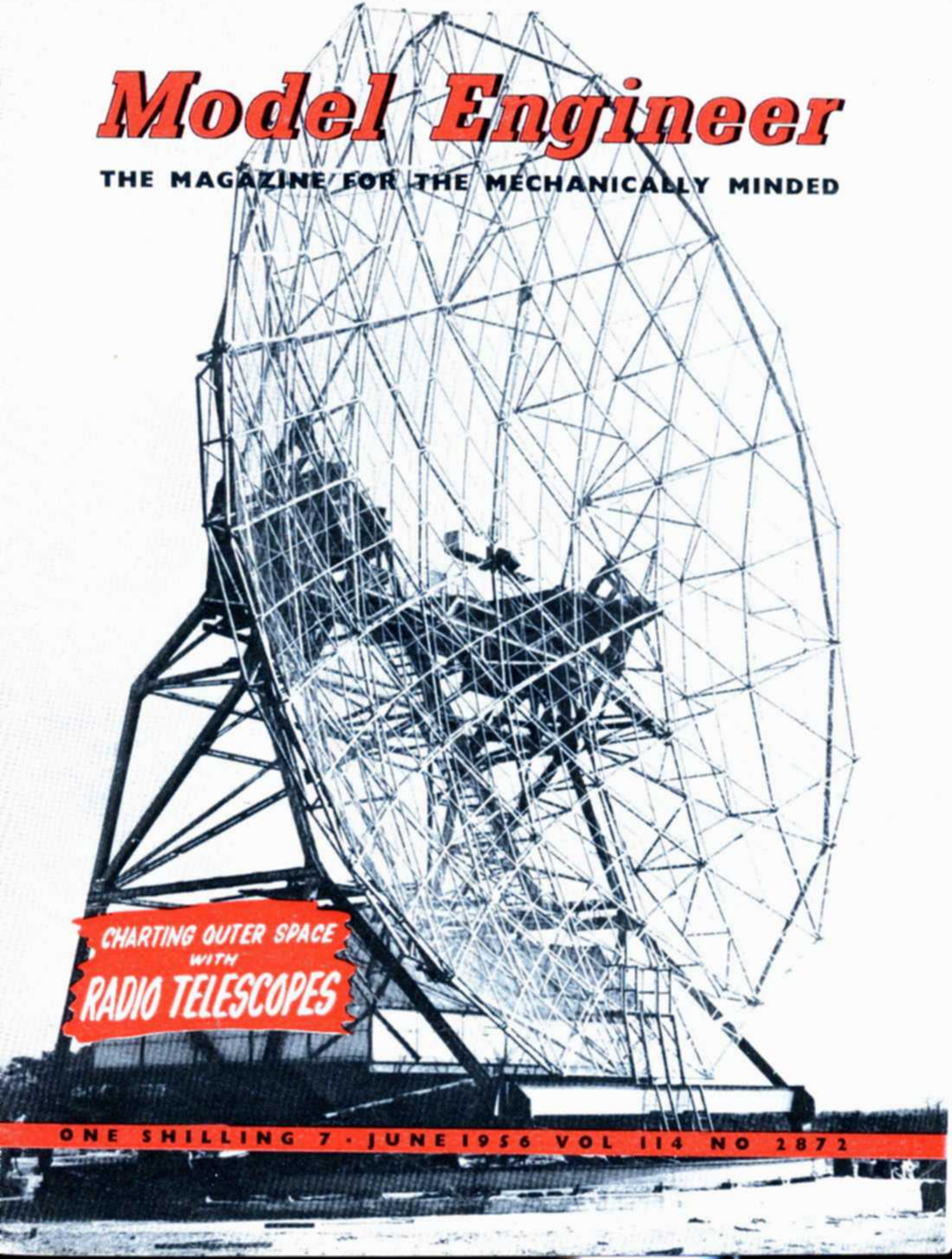
Model Engineer

THE MAGAZINE FOR THE MECHANICALLY MINDED



CHARTING OUTER SPACE WITH RADIO TELESCOPES

ONE SHILLING 7 · JUNE 1956 VOL 114 NO 2872

Model Engineer

7 JUNE 1956
VOLUME 114 No. 2872

Published every Thursday

Subscription 58s. 6d. (U.S.A. and Canada $8.50) post free

IN THIS ISSUE

NEXT WEEK

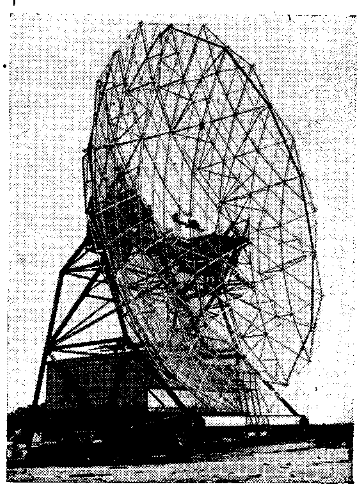
Modelling tramcars: F. J. ROCHE *recalls the heyday of the tramcar and gives some useful hints to those who like modelling these fascinating vehicles. The story of the gyro compass as a modern navigational aid; the final details of L.B.S.C.'s " Ivy Hall "; and a pictorial feature showing the constructional stages of the famous Bristol Proteus engine are among the many bright articles in our next issue*

COVER PICTURE *This radio telescope, the largest in the world, was inaugurated by Queen Juliana of the Netherlands last month at the Dutch village of Dwingeloo. On page 929* JOSEPH MARTIN *tells how these instruments probe beyond the limits of the visible universe*

CONTRIBUTIONS INVITED

MODEL ENGINEER is always on the look-out for first rate articles and readers are invited to submit contributions. Constructional details of models, how outstanding models have been built, historical and evolutionary articles of mechanical interest: there is a wide range of subjects. Photographs or drawings should accompany manuscripts which should be sent to The Editor, Model Engineer, 19-20, Noel Street, London, W.1. Please enclose stamped addressed envelopes for the return of MSS.

No correspondence should be addressed to individuals



SMOKE RINGS

FROM RECENT reports from the U.S.A., I gather that the electronics engineers over there have almost succeeded in making the science-fiction fan's nightmare—the machine that can reproduce itself.

I have no other details other than that this device can do nothing else except make more machines exactly the same as itself, so we will not be over-run by swarms of clanking robots just yet.

Seriously though, this machine is a very important step forward as it can carry out a small series of unrelated tasks and the principles of its design will be of immense value to industry.

Thinking machine

ONE OF the latest electronic calculating machines has the uncanny ability to think for itself—although in a limited fashion.

If a fairly involved problem involving, say, three possible solutions is thrown at the machine, it will take into account all the relevant factors and adopt the course that seems to be the most sensible.

It looks as though Michael Oxley's football pool forcaster/bomb-sight computer is not so far removed from fantasy after all !

Valves in the head

ALTHOUGH I may be sticking my neck out by writing this I can only record my joy at the thought that the side-valve engine is gradually dying. The o.h.v. unit is so much neater and more efficient (and more adaptable) and the *circa*-1930 bugbear of valves breaking is as out of date as the dodo.

What I would like to see now is a move towards the adoption of the overhead camshaft. The push-rod o.h.v. engine seems a curious mixture of high efficiency and a most unenlightened transmission system. The thought of eight push-rods dancing up and down (three points of contact on each—24 in all !) at engine speeds of 4,000 r.p.m. is a bit alarming.

The overhead camshaft has fewer points of contact and the entire system is rigidly controlled with much smaller chances of valve bounce. Why then, is the push-rod retained ? I could not say, but roll on the o.h.c. engine—preferably chain driven.

Built for abuse

IN AN office discussion recently, some of us tried to pin-point the reason for the overwhelming popularity of the petrol engine in the road transport world.

Although it is not staggeringly efficient and has a fantastic number of small moving parts—the failure of any one of which would mean a complete engine breakdown—the i.c. engine is a remarkably reliable piece of machinery, and it is possibly this factor that is the chief reason for its success.

If you consider for a moment the treatment a motor-car engine often receives at the hands of a non-mechanical driver it is quite surprising it lasts for more than a couple of thousand miles.

Valve types

Perhaps one of the most remarkable components of a car engine is the valve gear—especially the exhaust valve. It spends most of its time being seared by a flame of such heat that it glows cherry-red for quite a major proportion of its working life. Yet how often does one hear of an exhaust valve breaking up ?

Nevertheless, I am mildly surprised that the " valveless " two-stroke engine has not had more attention than it has. True, there are thousands of lightweight motorcycles and three-wheeled cars powered by it, but the number of family-type cars using two-stroke engines has always been very small.

Bogey laid

The pre-war complaints regarding erratic firing, oiling-up plugs, starting difficulties, the need for constant attention, etc., do not carry much weight nowadays and the supreme simplicity of the two-stroke in addition to its almost unlimited capacity for hard work more than cancel out the bother of the odd plug whiskering.

From this you will probably gather I am something of a two-stroke enthusiast. I will not deny it but I think my arguments will stand up on their own!

Steam rollers for sale!

ANY ENTHUSIAST who would like a full-size traction engine or steam roller in his back garden upon which to model a scale version may be able to satisfy such a whim. For, believe it or not, there are traction engines for sale on the home market. Here are the details extracted from a letter sent by a thoughtful Cambridgeshire reader.

In Tralee, Ireland, there are a small number of steam rollers and traction engines for sale. Offers and inquiries should be sent to Box CD3491, The Surplus Register, 17, Nottingham Street, London, W.1.

At Sleaford, Lincs, Mr. A. M. Cole, of Eastgate, is offering for sale a 10-ton Aveling steam roller built in 1926. It has scarifiers and is "in good condition, ready for working."

Another Aveling steam roller, the 7-ton version, is being sold by Sangwin Ltd., of Sculcoates Lane, Hull, who also wish to dispose of a 10-ton Fowler.

Danger—no brakes

IN THE article in this issue, L.B.S.C., when describing the brake gear for *Ivy Hall*, makes a little joke about locomotives with elaborate brakes. The locomotives' performances were so poor, however, that the brakes were entirely superfluous!

The remark reminded me of some of the early Bugatti cars. They were very quick indeed, but their brakes were astonishingly poor and the indignant owner of a slightly bent Buggati complained bitterly to the famous designer about the feeble stopping power of the car.

That worthy's answer was: "Sir, I design my cars to *go*—not to *stop*."

B.R. ends third class

THIRD CLASS officially disappeared from British Railways on Sunday, June 3, and there are now only two classes, first and second. This applies also on the shipping services of the British Transport Commission and on other shipping undertakings with which British Railways make through bookings. The change has been made to conform with the abolition of third class on the railways in Western Europe.

The fares in the newly-designated second-class accommodation are those which otherwise would have been charged for third-class travel.

Only first-class compartments and coaches are to have the class shown on the outside. Booking office and other station signs will be altered or replaced as soon as possible, temporary notices being exhibited in the meantime. The existing stocks of third-class tickets will continue to be issued until present stocks are exhausted when new issues will be printed.

Wrong scale

THE SCALE of the model of s.s. *Strathallan* in the issue for May 31 was wrongly given as ½ in. It should have been ⅛ in.

Robot weighbridge

IN THE goods station in the northern part of Rotterdam there is being installed a weighbridge of quite a new type. Its chief purpose is to weigh railway wagons, but it not only does that but it actually weighs only those that are intended to be weighed!

The bridge is situated on the hump of the marshalling yard and is provided with an electronic brain and buttons that correspond with the positions of the wagons in the train. If the fourth, twelfth and forty-third wagons require to be weighed as the train passes over the hump, buttons 4, 12 and 43 are pressed and the weighbridge weighs only those three wagons. In a hut alongside the hump the weight of each of these three wagons is automatically recorded on a strip of paper.

At the present time all this sounds marvellous, even uncanny; but in due course I am sure it will be merely commonplace.

An odd scale

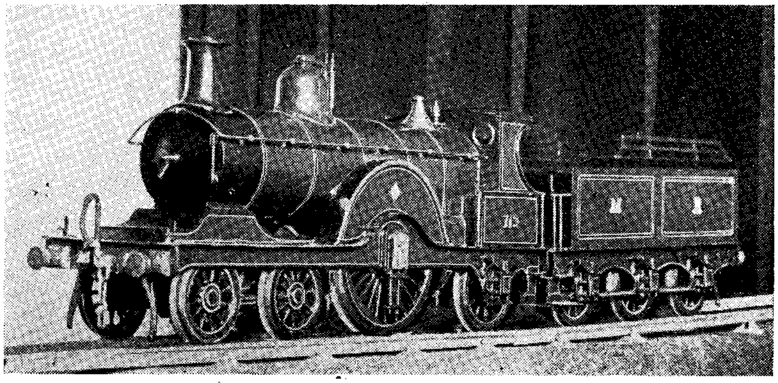
I HAVE BEEN looking at an old photograph of what must have been, in its day, quite a fine model of a well-known single-driver locomotive and tender. The model is very fully detailed and apparently well constructed and nicely finished; its date would be about fifty years ago.

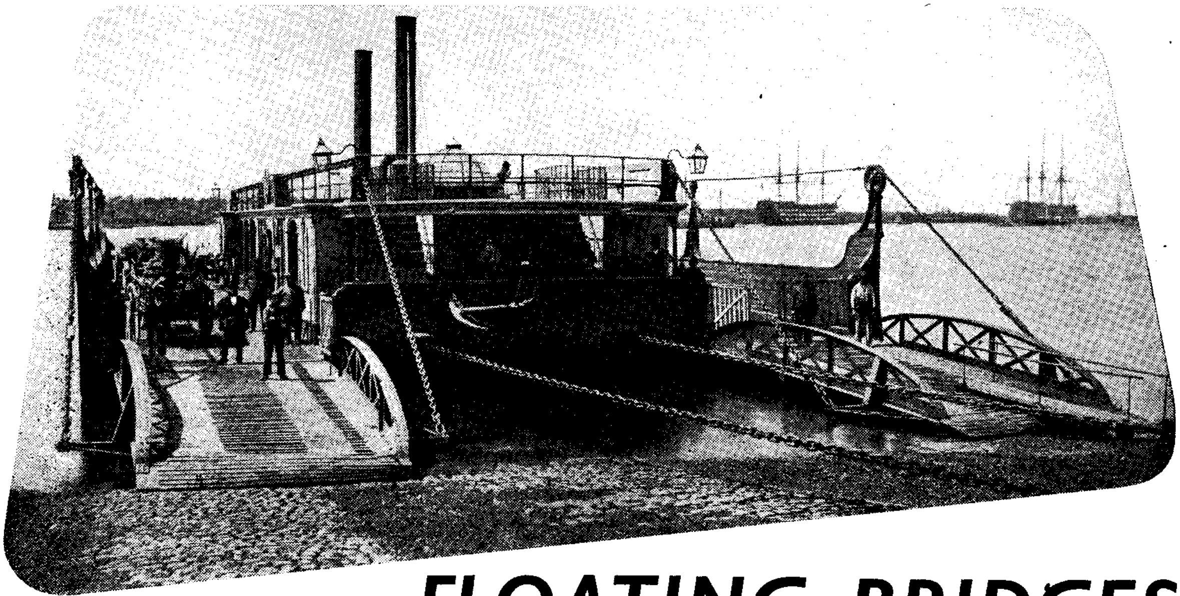
But it is built to the extraordinary scale of 1/9 of full size; that is a scale of 1 1/3 in. to the foot, which gives a gauge of 6 5/18 in. Whatever could be the reason for using such a scale? Quite apart from the extremely awkward fractions involved, it means that every detail for that model had to be made specially.

But then, the same is necessary for any true-to-scale model; so probably the awkwardness of the scale did not matter very much, and it may have been due to the fact that the drawings were taken from some reproduced working drawings in a technical journal.

These were seldom, if ever, to any proper fractional scale that an ordinary individual would use. There are some in the M.E. office that work out at 23/49 in. to the foot!

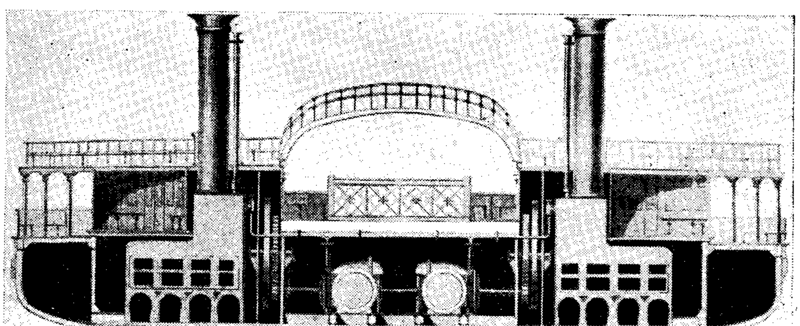
A Midland Railway Single which was built to the odd scale of one-ninth. See "An odd scale"

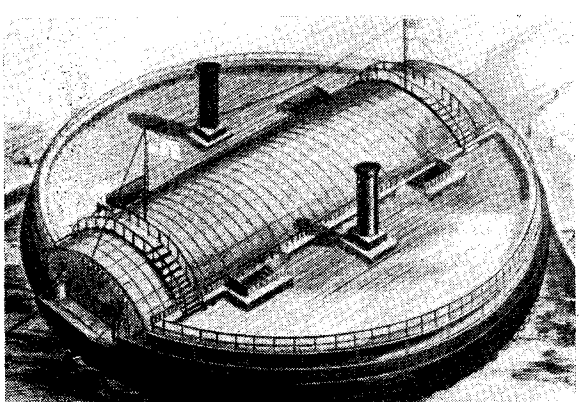




FLOATING BRIDGES

Where it is impracticable to bridge a river or tunnel beneath it the ferry provides a sound alternative. C. E. PAGE tells of the stirling work done by these " floating bridges "





Top of page: Stove-pipe hats to match stove-pipe funnels! The ALEXANDRA *ferry in her heyday*

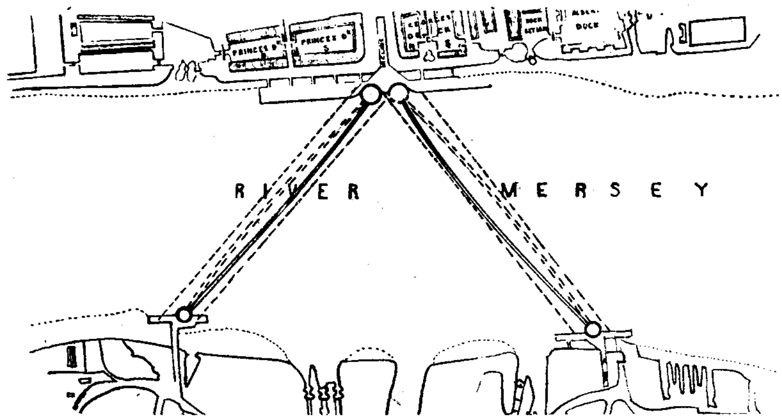
Above: Cross-section of circular ferry which was designed by G. Lister

Left: Lister's revolutionary ferry. It was proposed in 1866 *for the Liverpool-Wallasey run*

THE TRANSPORT of passenger and vehicular traffic across harbours, estuaries and rivers without interfering with shipping has always been something of an expensive undertaking, particularly if a high-level bridge, with its attendant approach roads has to be built. In many instances, however, mainly for financial reasons, either a free-floating ferry or a " floating bridge "—chain-ferry as it is sometimes termed—is used, in which latter type the ship literally pulls herself through the water by means of chains, the shore ends of which are firmly anchored at either end.

There are several floating bridges or chain ferries in this country, but probably one of the best known of all is that which regularly plies between Portsmouth and Gosport, daily dodging watercraft of all types and sizes from aircraft carriers to submarines.

The private company operating this ferry, the " Port of Portsmouth Floating Bridge Company," was founded in the year 1838, but the idea of a chain ferry between Portsmouth and Gosport had been projected as early as 1834 when an Admiralty



The Liverpool-Wallasey ferry route as devised for Lister's circular chain ferry

Board of Enquiry under Sir F. L. Maitland turned the project down on the grounds that the navigation of the harbour, which is Crown Property, would be interferred with badly. This regrettable decision delayed the running of the first floating bridge until 1840.

Then a few years later the chain ferry-boat *Albion* appeared on the scene, to be followed in 1864 by another vessel which is now no less than 92 years—repeat, 92 years—old, but is still as active as ever, faithfully rumbling and clanking to and fro across Portsmouth Harbour just as happily laden with motor cars and lorries as she was when dealing with horse-cabs and drays in the days of her youth.

This amazing old ship, now named *Alexandra*, is not a "ship" at all in the strictest sense of the word, for she's always at "anchor"! Like all chain and cable ferries, she is without a fore and aft, and has neither port nor starboard; for she follows her guiding chains without question and never puts about. All this sets a pretty problem when it comes to locating anything aboard.

"Outside" and "inside"

One cannot refer to "the 'port' engine," or "the 'aft' boiler," so the side of the ship nearest to the sea is termed the "outside" and the other side the "inside," and everything aboard is named and indicated accordingly. Similarly, the boilers and other gear duplicated at either end of the vessel are termed "Pompey" or "Gosport," according to which town they are nearer. Aboard ship quite a queer nomenclature indeed.

Built in 1864 by Messrs. Lewis and Stockwell, the *Alexandra* power-plant consists of a two-cylinder high-pressure horizontal condensing engine made by Messrs. James Watt, of London. Cylinders are 27 in. × 36 in., and steam pressure is 75 p.s.i., with a condenser vacuum of 15-20 p.s.i. The engines will do their job quite effectively, however, on 35 lb. of steam and 12 lb. of condenser vacuum.

10 ft. dia. chain-wheel

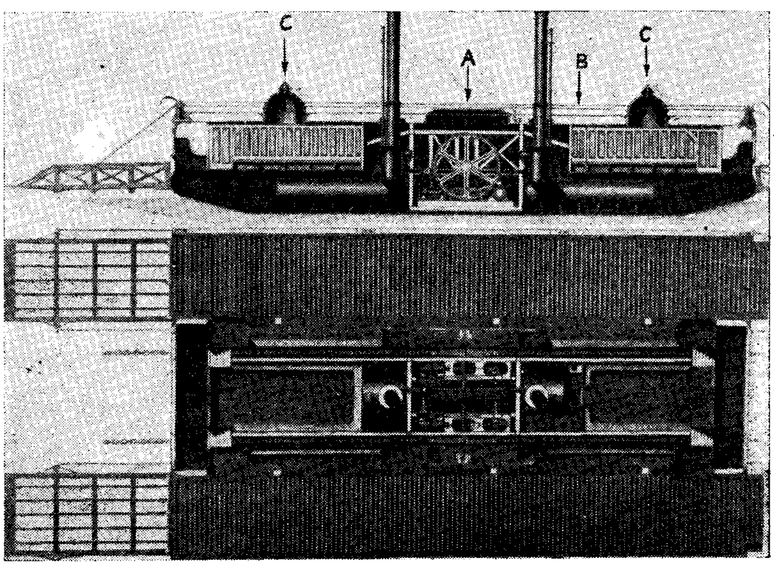
Mounted centrally on the crankshaft of the engine is a 25-tooth pinion with teeth 10 in. broad, which meshes with a 10 ft. dia. spur-wheel which is a single casting carrying 128 teeth in two 5 in. wide rings—making a 10 in. wide wheel-face. The pitch of the teeth is 3 in. Mounted at either end of the spur-wheel shaft is a 10 ft. dia. chain-wheel over which pass the 10-ton chains, each with its 3,000 10 in. links of good old-fashioned "Best Staffordshire Iron" $1\frac{5}{8}$ in. round section. Each chain is 1,938 ft. long, and on each trip the massive chain-wheels turn nearly 60 times.

As will be seen by the plans of the ship when she was built, two boilers, each 22 ft. long and 5 ft. 9 in. dia. were fitted, with 4 ft. flues passing up through the steam dome; but these longitudinally-placed boilers have long since been replaced by transverse ones. Gas-lighting was used aboard in the early days, a small gas-holder at one end of the Gosport bridge being filled once a day from shore, but now electric lighting, derived from a small self-contained plant, is used.

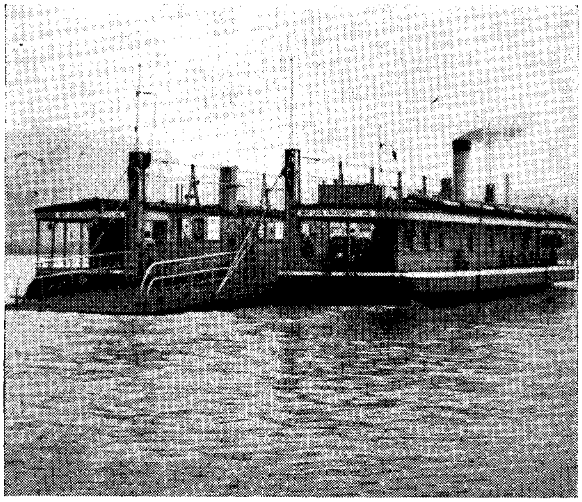
And now for a few dimensions: The *Alexandra* is 100 ft. long, to which must be added two drop "prows," each 30 ft. long. She was 60 ft. in the beam, overall, with a depth of hull under the deck-houses of 12 ft. and under the carriageways, 6 ft. There were two watertight bulkheads, and the hull plating was $\frac{5}{16}$ in. thick, reinforced with 5 in. × 3 in. × $\frac{7}{16}$ in. angle-framing placed 18 in. apart. Three-quarter inch rivets were used throughout on the hull. A second ferry-boat, the *Duchess of York*, built in 1892, is now on the stocks at Gosport undergoing major repairs and a refit.

A few miles to the west of the Portsmouth to Gosport Floating Bridge is the Southampton to Woolston ferry, upon which the principle of haulage is slightly different. Instead of the two massive chains, $1\frac{1}{2}$ in. dia. steel cables are used, each of which weighs over 35 cwt. and is formed of 36 strands of No. 12 S.W.G.

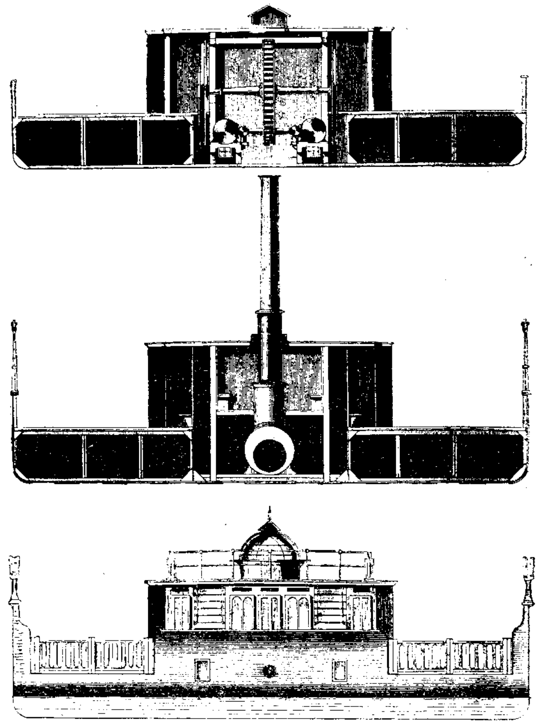
Side elevation and plan of Portsmouth-Gosport "floating bridge," ALEXANDRA



FLOATING BRIDGES . . .



The Southampton-Woolston "floating bridge"



Sectional views of the Portsmouth ferry

steel wire wound around a hemp core. The "up-river" or north cable alone takes the drive from the ship's engines by way of an 8 ft. 6 in. diameter wheel fitted with coned segments around its circumference to take up the wear in the wheel. The "down-river" or south cable is only an idler which is merely rove through the guiding and locating rollers.

The one-sided pull produced by this arrangement tends to make the ferry "crab" should the river be strongly ebbing or flowing, and as the Itchen, in company with Southampton Water, gets one tide up Spithead and another up the Solent every day this "crabbing" effect is often very noticeable.

It is interesting that one of the outstanding differences between chain and cable ferries is the latter's disadvantage by reason of its much lighter cables not dropping back on to the bed of the river behind the vessel as it proceeds on its way. This makes it very risky for normal shipping to pass too closely either ahead of astern of the ferry—a manoeuvre which is by no means so dangerous in the case of a chain ferry. Even so, on one occasion, with a very low ebb tide, even the 10-ton chains of the Portsmouth Ferry were not heavy enough to submerge sufficiently to be out of the way of a passing destroyer's keel, which neatly rasped out an inch-deep groove in one of the chain links.

The Southampton Corporation Floating Bridge was at one time known as the Southampton and Itchen Floating Bridge Company, and its early vessels are worthy of brief notice. They are numbered consecutively—not named. Nos. 1, 2 and 3 were passenger ferries, while Nos. 4, 5 and 6 were vehicular; No. 4 being fitted with cattle-pens. No. 7 was sunk on 8 March 1928 as the result of a collision with the steam tug *Fawley*, which was fortunately hauling a "dumb" barge at the time and rescued No. 7's passengers. No. 8 (1896), No. 9 (1900), and No. 10 (1928) are still in service; No. 10 being now in dry-dock.

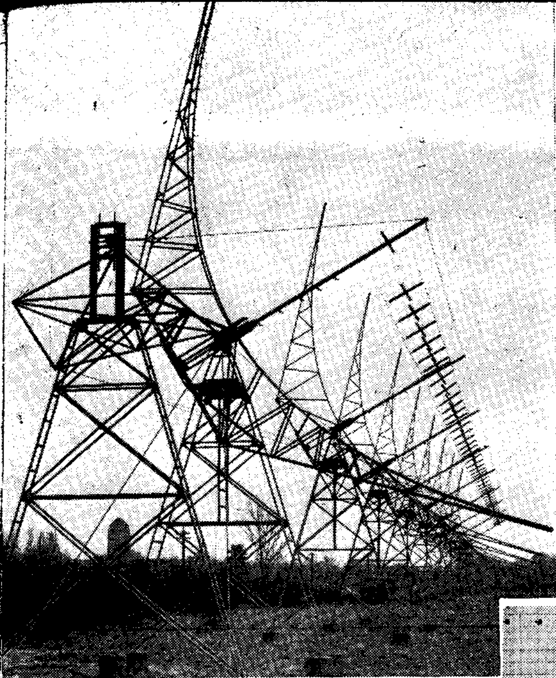
The engine of Ferry No. 9 is a two cylinder compound vertical beam, with 28 in. × 22 in. low-pressure cylinders and 14 in. × 22 in. high-pressure. The engine is non-condensing. Boilers are fed with water through an Aquastat electric softener powered by a 1½ h.p. diesel which also drives the dynamo for lighting the vessel. The teeth of the big spur-wheel were originally made of seasoned oak, but as they were both noisy and broke readily, hornbeam, lignum vitae and greenheart were successively tried without success, and compressed linen was eventually used which, though very expensive, has been giving good silent service for over five years.

Details of the surviving ships on the Southampton run

	Steam Pressure	Teeth on Driving Wheel	Beam	Length Hull	Length Prows	Draft	Builders
	p.s.i		ft. in.	ft. in.	ft. in.	ft. in.	
No. 8	85		41 7	91 0	33 4	2 4	
No. 9	95	104	47 0	91 0	33 3	2 9	Munday & Karney Ltd.
No. 10	100	200	49 0	92 3	33 6	2 6	Day & Somers Ltd.

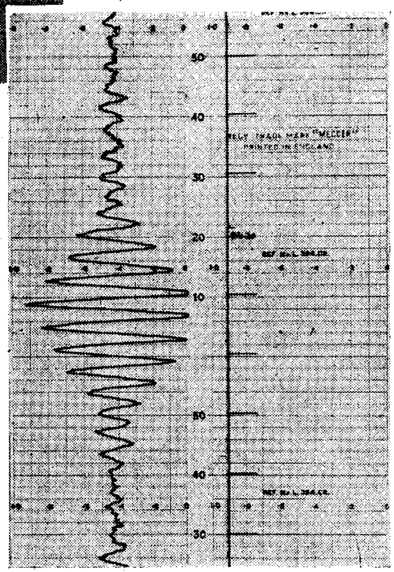
Heavy wear

The driving cables are in continual need of replacement, the driver lasting only nine months and the idlers giving about 20 months' wear. The cables are maintained taut by a two-ton weight at each shore end which hangs in a 12 ft. deep pit. They are connected to short lengths of chain at each end by steel "bottle-shoes," into which are driven wedge-shaped steel "fids" over which each of the 36 strands of wire composing the cable are spread out by hammering. ▣



THE WAY to THE STARS

"Straight from the imagination of H. G. Wells . . ." JOSEPH MARTIN discovers near the old-world village of Grantchester an array of skeleton-like structures tilting towards the heavens. The answer: Radio Telescopes



ONE SUNNY MORNING a few weeks ago I stepped off a country footpath near Rupert Brooke's Grantchester and listened to the sound made by an unknown star more than a thousand light years from the earth.

Ever since Rupert Brooke died on Scyros in 1915—at four minutes to five on the afternoon of April 23, which is St. George's Day and Shakespeare's birthday—Grantchester has stood as a symbol of the English village tradition and, indeed, of England itself. Americans go there, hoping for honey with their tea and, in the less habitable parts of the Commonwealth, mining engineers try to recall a few lines of "The Old Vicarage" while the rain beats down on a tin roof. . . .

Many of the pilgrims include the sister village of Coton in their walk through the countryside. You can, therefore, imagine their astonishment when they are suddenly confronted with a mysterious piece of apparatus straight from the imagination of H. G. Wells. There are several of these constructions near the pathway. From a huge skyward-pointing bowl which might vaguely remind a housewife of a wire cover for keeping flies off the Sunday joint, the eye turns in equal amazement to a row of nine quite different structures resembling—in so far as they resemble anything—a perchful of birds with long necks and tails or a series of sculptures inspired by "The Unknown Political Prisoner."

Top: The Cavendish Laboratory aerials. In the background is the tower of Cambridge University Library

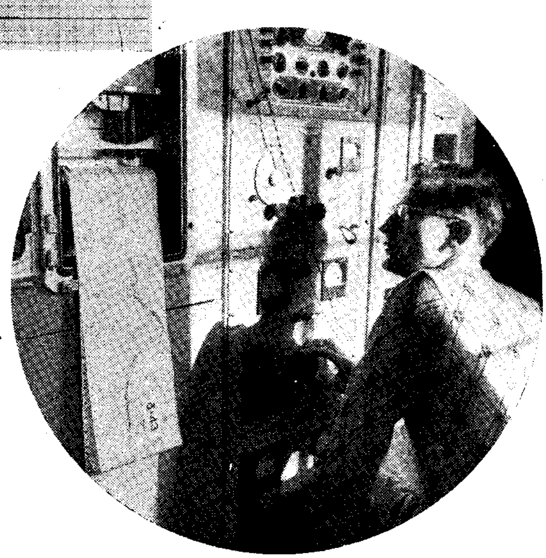
Middle: Milliammeter recording of a star. The signal strength gradually builds until the star is in the direct aim of the telescope

Right: The radio telescope at the Manchester University experimental station at Jodrell Bank, in Cheshire

Even in Cambridge itself—for Grantchester lies, of course, by the Granta or Cam—there are many who do not know that the strange erections behind Grange Road are radio telescopes for penetrating the inconceivable immensities of Space. Indeed, a friend of mine who took a science degree at Cambridge was unaware of their existence until he discovered them during a country walk at Easter. Afterwards he rang me up in London: "Have you ever seen those extraordinary things near the Coton footpath?"

Even to a scientist the radio telescopes are extraordinary. Arts men tend to speak of them, when they refer to them at all, in somewhat different terms: "Oh," one of them said to me, "you mean The Monstrosities. . . ."

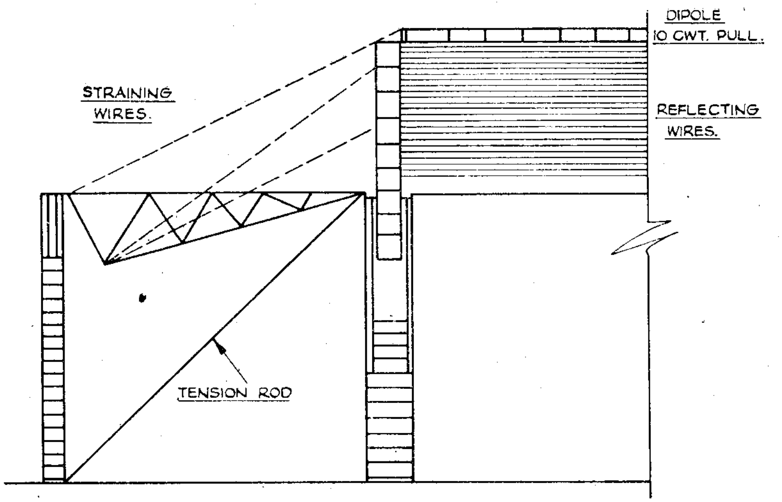
The radio astronomers of Cambridge have had to work like other



THE WAY to THE STARS . . .

pioneers. Yet their telescopes, though far from elegant, are impressive when studied from a good angle, and even a little awe-inspiring when account is taken of their purpose. Set in a clear, unencumbered vista they would have a kind of majesty.

It was here, on the edge of Cambridge, that much of the most important pioneering work in radio astronomy was done. This pioneering—if the word is not meaningless in science, where all is an endless quest—still continues day and night. Radio astronomy is regarded not as a new field in the oldest of the sciences, but as a science on its own, the young sister of astronomy and astrophysics. So far it has had a life of less than 10 years.



In designing the aerials Mr. Mackay had to allow for a complicated system of strains. The structures were built at his engineering works at Cambridge

Aerial noise changes

Yet its origins as is so often true of new developments, belong to a period considerably earlier. Nearly a quarter of a century ago, at the end of 1931, K. G. Jansky an American radio engineer at the Bell Telephone Laboratories, was investigating atmospherics on a wavelength of 15 metres when he discovered that the aerial noise changed in the course of 24 hours—that is to say, while the earth was rotating. It varied in intensity and it arrived from different directions. Therefore, Jansky reasoned, the source was a point which remained steady while the earth revolved. Such a point could exist only beyond the terrestrial atmosphere—in outer Space.

Following this piece of detective work with further investigations, Jansky suggested that the source of the noise was distributed along the vast stellar system of the Milky Way, and that it was at its strongest towards the centre of the system, the galactic system around which our sun is spinning with billions of other stars. Later, as the area of inquiry widened, radio amateurs came to play a part in the creation of this new science. Unknown to themselves, their reports of inexplicable hissing noises, often succeeded by a complete fade-out, were important clues for the guidance of the first radio astronomers.

In those days the significance of Jansky's discoveries was not fully appreciated. It fell to the post-war scientists, aided by the development of radar in the war years and by the improvement in radio techniques, to establish the radio telescope as a revolutionary means of exploring the universe. What possibilities it may hold no man can know; we are only at the beginning.

In a sense astronomy itself has only now begun. Today the signs in the heavens point to a tremendous upheaval in science through the development of astronomical inquiry. The sense of being on the threshold of a new epoch finds a popular expression in the fantasies of Space travel, which are read even in remote parts of Russia. It is also expressed in Fred Hoyle's broadcasts and in the public response to them. Mr. Hoyle came out of Cambridge to talk with starry brilliance of such mysteries as the buckled surface of Energy-Space, and millions who had only a passing interest in astronomy realised that they were being offered a Book of Genesis for the Atomic Age.

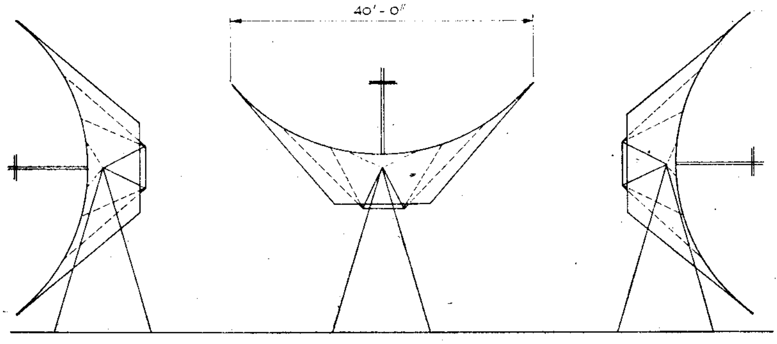
The beginning of time

The most thrilling revelation is that we live in an atomic universe. In the beginning was the atom. Suddenly we were shown the universe as a process in atomic fission continuing through aeons upon aeons of time and through billions of miles in distance; a process without end. And hard upon this we learnt a further detail; in the beginning, too, was hydrogen.

Such is the cosmos that the radio astronomers are helping to explore and map. Their instrument differs from the optical telescope in that it uses radio waves instead of light. Radio waves and light waves are essentially similar; scientifically the only difference between them is in wavelength. Heinrich Hertz proved this fact by experiment exactly 70 years ago—in 1886—and added, as a further gift to the future, that radio waves were reflected from solid objects. Again, as far back as 1900, Sir Oliver Lodge was trying to receive radio waves from the sun.

One part of radio astronomy is concerned with receiving electromagnetic vibrations, as in ordinary radio, and the other in transmitting

Donald Mackay's drawings for the Cambridge aerials



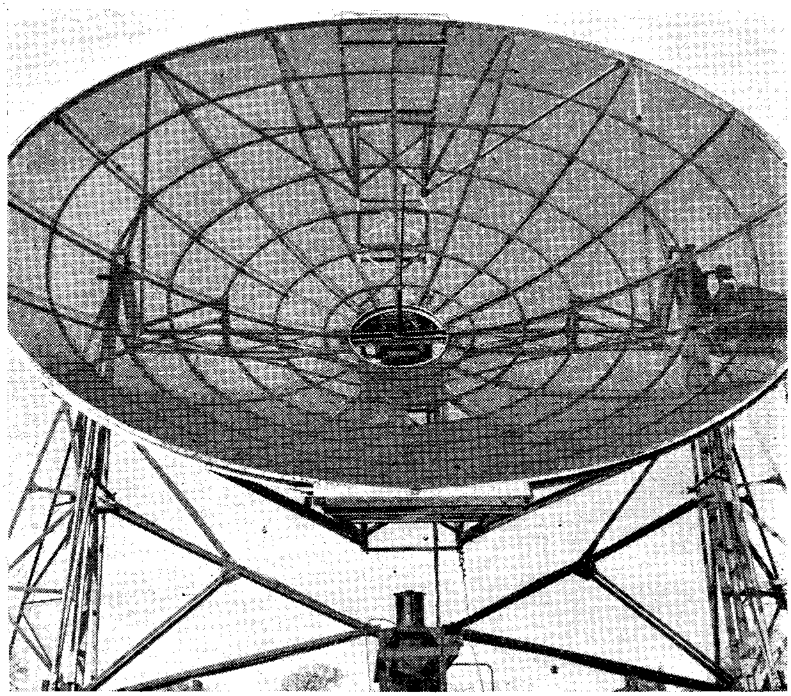
them and observing their echo, as in radar. The radio telescopes at Cambridge are devised not for bouncing radio waves off the moon or anything of that kind, but for the reception of waves from transmitters millions of miles away. Already Mr. Martin Ryle and his team have charted nearly 2,000 otherwise unknown stars beyond the range of any optical telescope. The waves from these radio stars, as they are known, were picked up by means of the line of aerials and reproduced as red loops on a chart.

From the aerials in the field the combined signals are led by a coaxial cable to the laboratory building and combined again in a very sensitive receiver. Although the signals are normally studied as the tracings made by a recording milliammeter which enables the observations to proceed continuously through every moment of the 24 hours, they can also be heard, if one wishes, in terms of noise.

While I was being shown the neat, blue panels ranged in the laboratory, Mr. Robin Conway, one of the young astronomers in Mr. Ryle's team, kindly detached a lead. I heard a sound like bacon frying. " You are listening," said Mr. Conway, " to a star more than a thousand light years away. The sound that you hear has been travelling towards us, as radio waves, throughout the greater part of the Christian era."

Some of the waves have journeyed through Space for a hundred million years—at the speed of light, which is 186,000 miles a second. When such fantastic periods of time are involved, it is possible to hear the sound of a star as it came to birth aeons ago, or the sound of a star that has long since died. The most dramatic illustration of this is provided by the Crab Nebula. In 1054 Chinese astronomers saw a star explode. While the ghost of this star is still visible as an expanding envelope of gas, an Australian radio-astronomer named J. G. Bolton obtained signals which are believed to have emanated from the star itself before it blew up into a supernova two years and nine centuries ago.

The frame of the Manchester University telescope



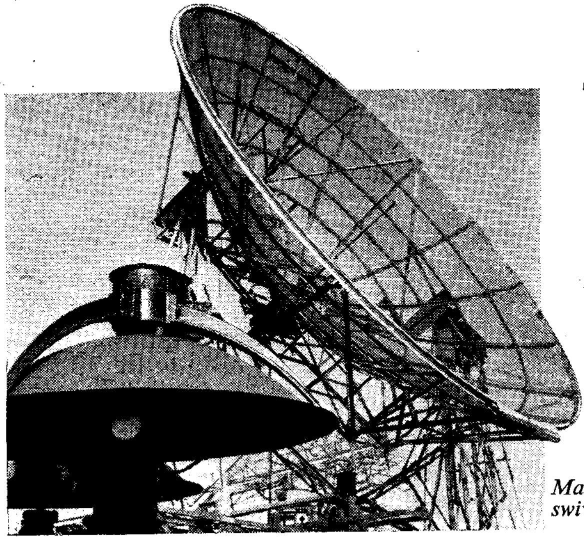
Another view of the telescope at Jodrell Bank

One of the Cavendish radio astronomers charmingly explained that he preferred the new science because it allowed him to go home at night and to look up at the stars without thinking about work ! No one who meets Mr. Ryle's brilliant team, or sees Mr. Ryle himself cycling along the footpath to his telescopes, will ever again imagine the typical astronomer as an old, bent gentleman with his mind somewhere among the moons in Saturn.

I had a surprise when I asked who built the apparatus which has found 2,000 stars. " A local ironmonger," said Mr. Conway.

The " local ironmonger " proved to be Mr. Donald Mackay, of the Britannia Works in East Road, Cambridge. Mr. Mackay is a young man whose grandfather, Donald Mackay from Burnt Island, set up as a wheelwright and blacksmith at Cambridge in 1914 and developed the business, with his son Duncan, to include general supplies and engineering.

It is impossible to understand the



THE WAY to THE STARS . . .

Manchester University's swivel-type telescope

difficulties of building a radio telescope without a knowledge of the special problems involved. Mr. Mackay had to provide for a complicated system of strains to counteract a twisting load at the end towers, and to evolve a method of revolving the aerials in stages of five degrees from horizontal South to horizontal North when only the essentials of the apparatus could be allowed inside the parabola. As a final requirement the structure had to be climbable and capable of bearing the climber's weight.

The public had an inkling of such problems as these in mid-April when Manchester University revealed that its giant saucer-shaped telescope at Jodrell Bank, the largest structure of its kind ever to be built, would cost £250,000 more than the £400,000 which had been estimated. About two years ago a decision was made to change the design of the telescope so that it could operate on shorter wavelengths. The chief problem was to make the reflector stiff without distorting it more than a tiny fraction from the true. With still shorter wavelengths an even greater degree of precision was necessary and, in consequence, the work has become more difficult and costly.

Nearly finished

At the moment the whole of the superstructure has been completely erected and work is proceeding on the bowl unit. The consulting engineers are Messrs. Husband and Company of Sheffield and the structural steelwork is being fabricated and erected by the United Steel Structural Company Ltd. of Scunthorpe. Needless to say, the telescope has been modelled in every detail. I am told by United Steel that a new model, showing the altered design, has been completed recently.

When the project is completed the surrounding countryside in the quiet parish of Barnshaw-cum-Goostrey, where the pioneers used to make their headquarters in an old fertiliser shed, will be dominated by an apparatus perfectly satisfying the schoolboy's conception of what a radio telescope should look like. Rising 300 ft. above the ground this altazimuth parabaloid radio reflector, as it is called, has a bowl 250 ft. in diameter carried on two trunnions 165 ft. 9 in. high and each weighing 17½ tons. The bowl consists of an outer ring girder in 16 parts, each 48 ft. long and 63 ft. 3 in. deep, and 16 main ribs. On the inside it has two miles of steel purlins on which will be attached the reflector material. The aerial is 62 ft. 6 in. long and is reached from ground level by walkways which also give access to a laboratory slung under the bowl and so constructed that it will level when the bowl is in any position. A diametral girder 40 ft. wide × 20 ft. deep connects the main towers, which measure 40 ft. × 20 ft. 3 in. at the base, and in its centre is a motor-room complete with an overhead crane. The towers are provided with a lift to a laboratory at trunnion level.

It is when the rim of the bowl is vertical that the telescope has a height of 300 ft. The whole tremendous structure, weighing 200 tons, is pivoted in the centre at ground level and is built to revolve on two circular tracks, the outer one having a diameter of 352 ft. 9 in. There are 12 bogies.

At Cambridge, on the other hand, the apparatus observes the radio stars passing into view as the parabolas are directed towards different areas of the sky through the earth's rotation. This form of radio telescope has its own particular value, as is shown by the decision to build another and larger one on the same principle.

Mr. Mackay is already building it. The universities, as we all know, thrive on a spirit of friendly competition, however fruitfully they co-operate, and so I shall not reveal any details of the new instrument, parts of which Mr. Mackay was kind enough to show me in his excellently-equipped workshops. He has constructed a model in Meccano. It works out conveniently to scale and he finds that many of his problems are solved in the actual process of building it.

All day, while housewives enter the shop at the front to buy curtain-hooks and pot-cleaners, Mr. Mackay and his staff are occupied at the rear with the task of building a radio telescope that will be the largest of its kind in the world.

Front-page news

While I was at the laboratory that day some abnormal signal, equivalent to shrieks, came through from that rather third-rate star which supports our insignificant little speck of a planet. Taking me to a small optical telescope near the door, the radio astronomers showed me on a piece of paper the sun-spots which the milliammeters indoors were recording in a different form. An hour later this violent activity on the sun was front-page news.

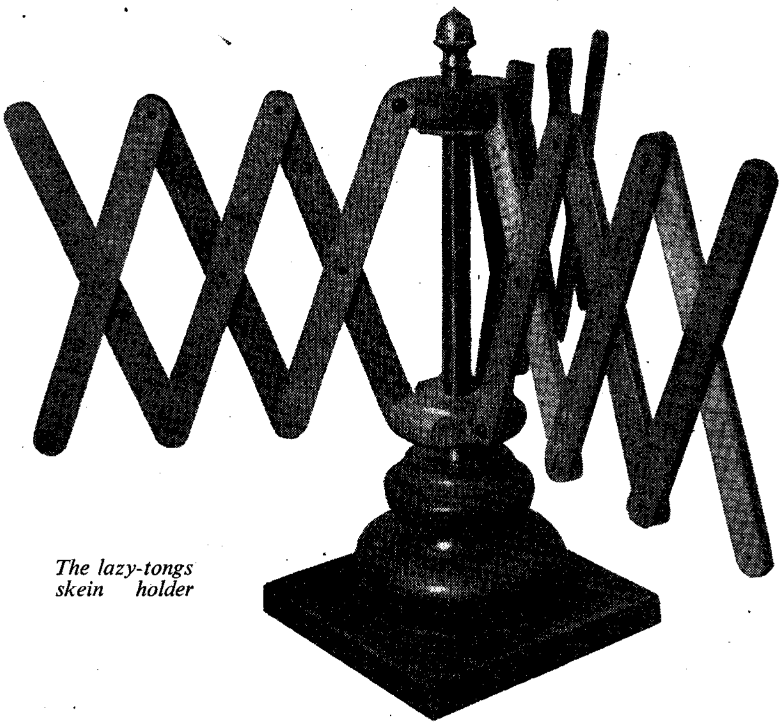
Sun-spots and solar flares are among the most important phenomena to be investigated by the radio telescope, and the pioneer work of Ryle and Vonberg in this field has been studied with immense interest by meteorologists. As we learn more about the stars, so do we learn more about the earth we inhabit.

There is, in science, a majestic continuity, and nowhere is it better shown than at the University of Cambridge. It was there that Clark Maxwell, first director of the Cavendish, propounded the electro-magnetic theory of light. It was there that the great J. J. Thompson, born 100 years ago, discovered the electron. It was there that Edward Appleton and his colleague, Barnet, proved that the Heaviside Layer, the electric ceiling above the earth, varied in distance from the earth's surface according to the time of day. All these discoveries have a bearing upon the radio telescopes on the edge of the Grantchester countryside.

Perhaps we should see the footpath from Coton as a symbol; a track worn by the brave and tottering feet of Man in his endless quest for knowledge and understanding. ■

An aid to home knitting that will relieve you of the back-aching chore of wool holding and also give you extra hours in the workshop. ARTIFICER outlines the details

A mechanical WOOL-WINDER



The lazy-tongs skein holder

ON SEVERAL OCCASIONS in the past I have described the construction of devices which, while considered by a few readers to be not really within the scope of model engineering, have been appreciated by the majority and have proved helpful to many, who consider, as I do, that any kind of mechanical work within the facilities of the home workshop is well worth while.

This does not mean that I exhort model engineers to become home handymen, or to devote the whole of their activities to prosaic "utility" production; but no model engineer need consider it beneath his dignity to make an occasional article for home use and this certainly makes an important contribution to domestic efficiency and harmony.

It will be noted that I have specifically referred to mechanical work; the many simple and unpretentious odds and ends for the home which are so frequently described by exponents of "do-it-yourself" are by no means to be despised, but they are not what I have in mind for the present series of articles. The subject dealt with is legitimately within the sphere of light engineering and gives a certain amount of scope for the use of the lathe and other tool equipment which the average reader of the MODEL ENGINEER is likely to possess.

A wool-winding appliance

Some 17 years ago I gave a description of a simple wool-winding machine which had been made by a friend who has since died; this was admitted to be of a somewhat primitive nature, though undoubtedly effective. It was criticised by one or two readers, but many more considered it worth while constructing and found it highly appreciated by their wives, mothers and girl friends.

During the war, when home knitting schemes were very much in demand, I was asked to make one of these machines myself but I decided that it was possible to improve on the design and I produced the version which is now to be described. Several of these have been built by myself and friends, many of whom have thereby been saved from the devastating ordeal of sitting up like a good dog and holding up their paws to support skeins of wool.

The original wool-winder was made as a single unit incorporated a rotating frame with adjustable carriers for the skein, and also a spool winder with a laying arm or spinner to form the ball of wool. In the improved appliance it was decided to separate the two functions and make it in two pieces thereby improving adaptability and reducing bulk so that it is easier to pack up and stow away.

Some users of the machine have not taken to the spool-winder part of it, preferring to wind the ball by hand in the traditional manner, but all without exception have found the skein holder useful—this view, beyond doubt, has been shared by their menfolk. It is thus worth while to make this part, even if the other is not required.

Tangled skein problem

While the use of the winder will undoubtedly speed up production and reduce labour under normal circumstances, it is only fair to point out that there is something it cannot do—namely, unravel a tangled skein. I have wrestled with this problem but so far have found no solution to it, and if any reader can find the answer, either as applied to this or any other winding device, I should be glad to hear of it. Tangled skeins, of course, are like accidents, in that they could and should be avoidable; care in storage and handling is the remedy, but they do happen even in the best regulated households.

The device as illustrated is not considered to be its final form; I had intended to clean up and "streamline" the design, possibly using castings or more elegantly shaped components in construction, but have not found time to do so up to the present. Wood is extensively used, and it is quite satisfactory, but there is scope for alternative materials which would enable greater compactness or lightness to be obtained.

The skein holder

This incorporates a pedestal with a vertical pillar which forms the pivot for the rotating member. The latter has three arms made from laths forming a trellis or "lazy-tongs," thereby enabling the radius to be adjusted as required to take skeins of varying size and also to fold up close to the pillar when not in use. To obtain this result, one of the hub discs is made a sliding fit on the tube which forms the bearing on the pillar, the other disc being fixed. When the discs are brought closer together the trellis is extended, and as the three arms must move simultaneously the system is self-centring.

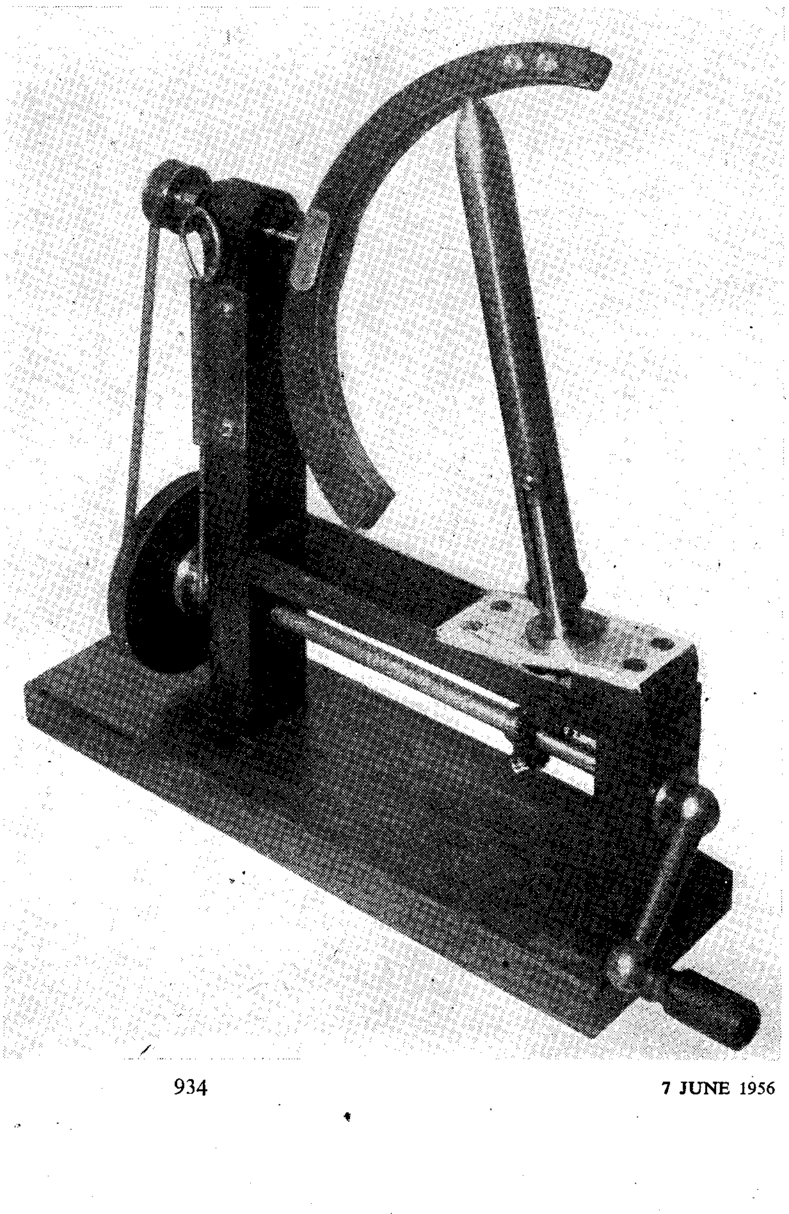
It would be possible to operate this adjustment by means of a screw motion applied to the upper disc, but no necessity for such provision has been found necessary, and it might even be found undesirable. With the friction normally present in a number of articulated joints, the arms stay put when adjusted and can be closed up instantly.

The pedestal may be of turned wood, as large and heavy as permissible to obtain stability. It would be helpful to load the base with a metal plate or lead filling for this purpose, but the example seen in the photograph has a square sub-base which enables it to be held down securely on a table top with a couple of spring clips. For use on polished furniture, a felt or baize facing on the underside of the base is desirable. The pillar may be made of mild steel, shouldered down and screwed to form a mounting bolt, and a metal thrust washer should be fitted on top of the base to take the weight of the rotating member.

The hub discs are made as shown in the detail drawing, hardwood such as oak or beech being suitable, and as already mentioned one is fitted tightly to the centre tube and the other free to slide. They are notched as shown to provide faces for the pivoted trellis laths which work on round-headed wood screws fitted tangentially in the discs. These faces should be truly radial to the discs, and note that these are both cut to produce the same "hand," for though they face each other the laths will be pivoted on opposite faces.

Similar hardwood is used for the laths, which number 18 altogether and should be identical in size and length, especially in location of pivot holes. Hollow rivets may be used for the joints or, as an alternative, small bolts with tight-fitting nuts; wood screws, in the very short length permissible, have not been found satisfactory.

The spool winder, showing the bevel-gear drive



The centre tube should be of 16-gauge, which will give an easy running fit on the pillar, but if thinner, a turn of foil may be sweated inside at each end to take up the clearance. If too tight a fit, it may be lapped out or bored with a $\frac{3}{8}$ in. D-bit.

The spool winder

This is also made mainly of wood and the frame, which is nominally $\frac{3}{4}$ in. thick material but more nearly $\frac{5}{8}$ in. when planed, may be built up by dowelling or morticing the joints, which are glued. The laying spindle is of $\frac{1}{4}$ in. dia. mild steel, drilled through $\frac{1}{8}$ in. dia., and the mouth of the hole at each end is carefully rounded and polished. It runs in a brass bush set horizontally in the upright member of the frame, and a $\frac{3}{4}$ in. grooved pulley is fitted to the outer end; this may be permanently secured by pressing on or sweating.

At the inner end is the bow or spinner, which may be made of hardwood or plastic board (the latter is preferable) and can be turned on the inner and outer contours which are eccentric to each other to produce a thicker portion for the balance weight. The best way I have found to secure this spinner is to fit metal clamping plates on each side, spanning the spindle hole with two screws to secure them.

The outer side of the spinner arm is grooved to form a channel for the wool, with a tangential hole to lead it from the inner side and a retaining clip at the extremity. This arm should be balanced so that the spindle will rest at any point of rotation (running freely, of course) by cutting the balance weight to the required length.

Shape of wool ball

By varying the inclination of the spool shaft the shape of the " ball " formed on it can be influenced; the angle of 15 deg. shown produces an oval cocoon or " cop " as it is called in the textile trade. This spindle runs in a long bearing which is secured at the required angle in the frame by any convenient means. A collar at the top of the bearing is fitted with a cross screw, the head of which drives the holder.

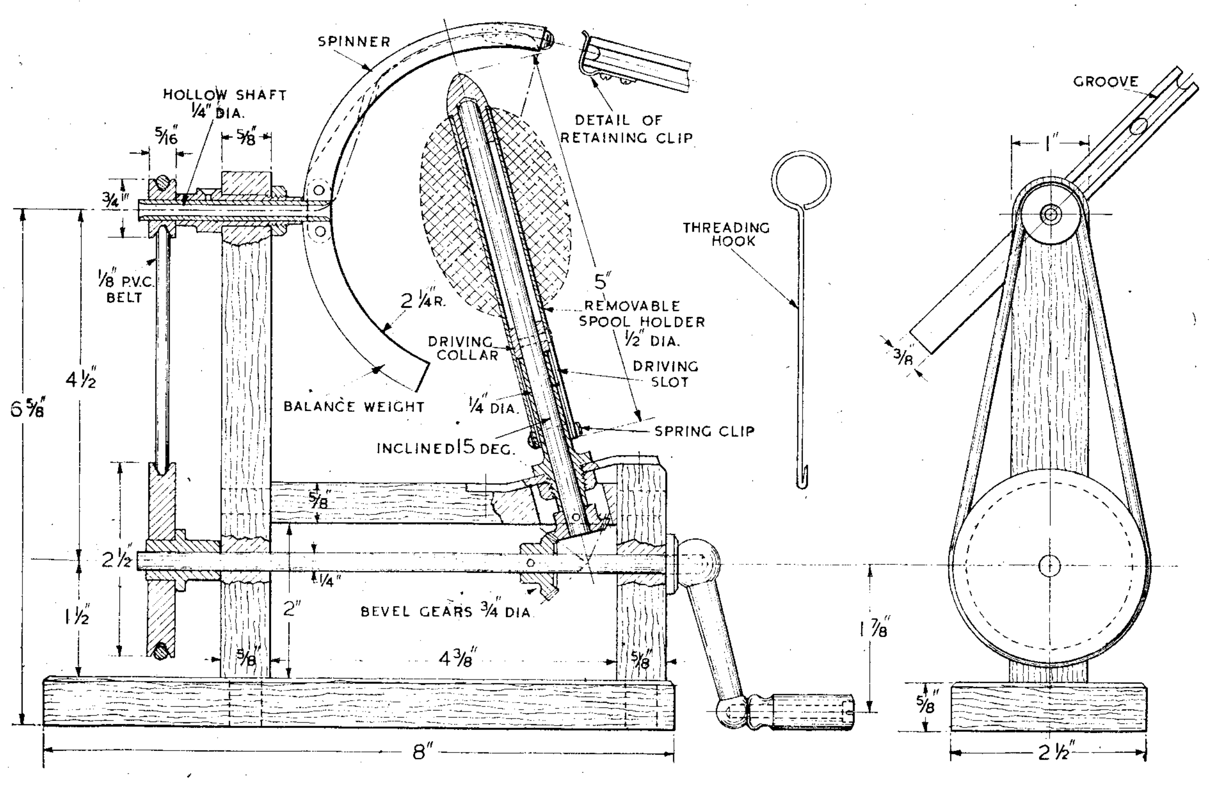
The latter is made of thin brass tube, with the conical head sweated in, the central hole in which locates on the top end of the spindle while the slotted lower end engages the driving screw on the collar. A spring clip on the holder provides a convenient anchorage for the end of the wool. This holder should fit firm enough to resist being pulled out of position but it should be easily removable.

A horizontal shaft running right across the frame carries the driving crank and the large pulley, also the bevel gear for driving the spool holder. Mecanno bevel gears were used and although they are intended for shafts at 90 deg. they run quite smoothly at the odd angle. If any roughness is encountered, however, lapping them with a mild abrasive, in position, will cure it.

Should it be impossible to obtain suitable gears it is practicable to use friction drive, one member being a bevelled metal disc and the other rubber-faced; it would, however, be advisable to make both of them larger than the bevel gears shown. Do not gear up this drive; the spinner should always run at least three to four times as fast to produce an even " latice weave " spool.

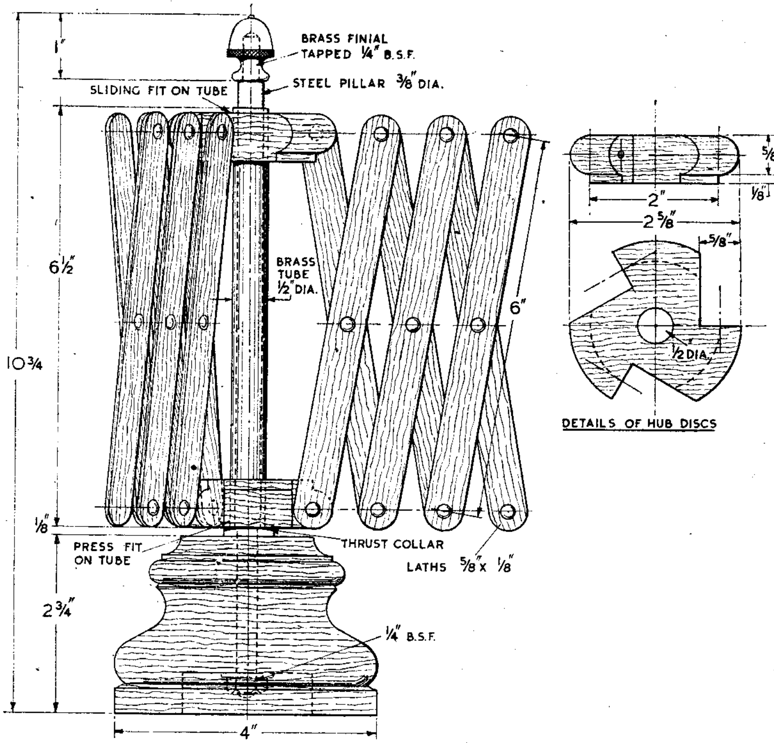
It is necessary to provide a hook of stout wire to assist in threading the wool through the spindle and the hole in the spinner arm. A holder for

The general arrangement of the spool winder



A mechanical WOOL-WINDER . . .

Constructional details of the holder

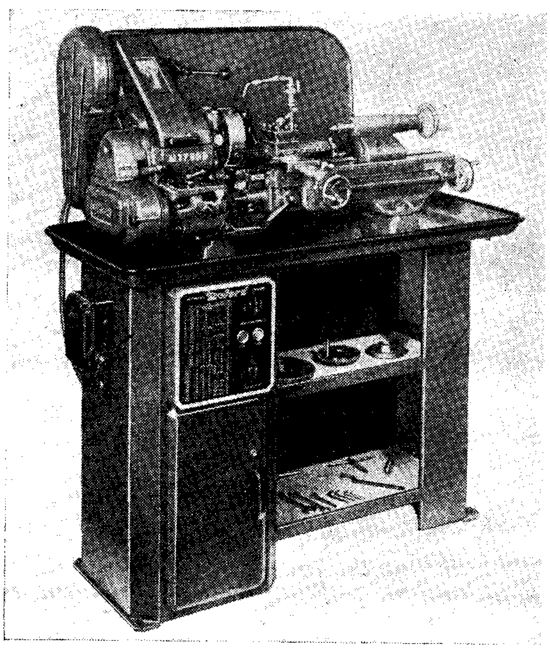


this can be provided on the frame, as shown in the photograph. In use, the winder is clipped to the table top in such a position that the wool leads fairly off the skein holder and through the spindle. After threading, the end of the wool is clipped to the spool holder and a half-hitch taken round its centre; then full steam ahead.

When the spool is wound, a few turns are taken on the outside and the end tucked in; it is slipped off the holder and the wool is taken from the inside so that it is not subject to involuntary unwinding or tangling; in fact, it may be said to be practically " kitten-proof " which, as many knitters can testify, is most unusual virtue. ■

THE MYFORD SUPER 7B LATHE

Though designed for industrial use this lathe offers attractions to amateurs



Some idea of the capabilities of this superb lathe are clearly shown in this picture

THIS LATHE represents the most up-to-date development in Myford products. It has been introduced primarily to suit industrial requirements, though its special features will undoubtedly prove attractive to many amateur users. It incorporates the 3½ in. Super 7 lathe with all the latest refinements, including a range of 14 speeds from 25 to 2,150 r.p.m., and a quick-change gearbox providing 48 threads and self-acting feeds.

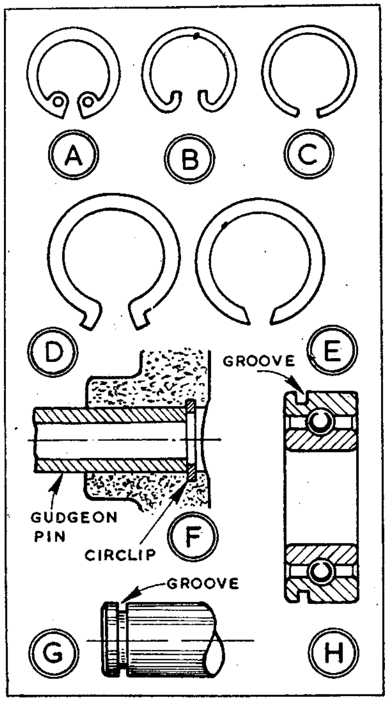
The pressed-steel cabinet stand contains a compact and readily accessible electrical control unit and isolator, with overload cut-out and no-volt release, also switchgear for the lathe motor and suds pump. Alternative accommodation for the latter, which is complete with coolant tank and service pipes, is provided either inside the cabinet or as an external and separate unit.

A large drip tray, with beaded edge and shaped so as to facilitate swarf removal, is provided and incorporates a flush-fitted suds outlet and drain plug. This lathe is capable of producing work to the most exacting limits of accuracy and surface finish and is equally suitable for toolroom, production or general workshop use. ■

Beginner's Workshop

CIRCLIPS

GEOMETER details the removing and fitting of some modern locating devices



NOT SO MANY years ago a circlip as a locating device was something of a rarity, not inspiring full confidence in engineers. Some thought it likely to work loose or jump out of its groove in use, to break from vibration, or soften or distort when subjected to heat—with more or less disastrous results.

Some circlips did, in fact, give trouble—from wrong material, wrong application or fitting. But modern examples are among the simplest and most reliable locating devices, if a few simple rules are followed.

Circlips, like split pins, are advisedly regarded as expendable items and used only once. Where side thrust is likely to be encountered, they should be of rectangular section, seating properly in accurate square-sided grooves. Round section types in half-round grooves may compress or expand (depending on the application) and push out. Such circlips should always be sunk in their grooves to at least half the diameter of their section. With circlips of soft material, which have to be squeezed into grooves, care must be taken to do this properly.

Common types

Popular types of internal and external circlips are shown at *A* to *E*. Type *A* is of rectangular section to fit a square-sided groove in a bore, and is provided with two holes for compressing with a suitable tool when fitting or extracting. Type *B* is also for a bore, and of round wire with the ends turned in for manipulating with narrow-jawed pliers. Type *C* is of round wire and may be fitted in a bore or on a shaft—sprung in or on, and levered and pushed out with a screwdriver blade. All these are hardened and tempered and, consequently, springy.

Type *D* for external fitting is soft, however, and of rectangular section provided with lugs at the ends for squeezing it into its groove. Type *E* is also rectangular section, but springy, and for external fitting—its ends being chamfered inwards to permit of easy levering out.

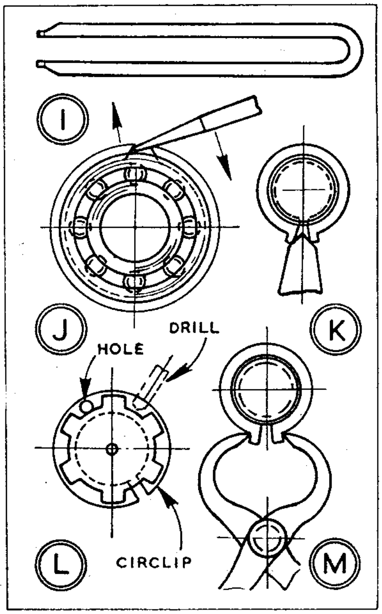
Common uses for type *A* circlip are for end-locating gudgeon pins in pistons, *F*, and for similarly locating bushes in needle roller universal joints. The circlip should only be used once, and great care exercised to seat it properly. Type *D* circlip fits in a groove, *G*, and is often used for car brake shoe pivots. Type *E* circlip is employed where a ball race, *H*, carries a groove in its outer member, the circlip then locating it endwise in the housing.

Piston circlips can be manipulated with small round-nosed pliers or a tool, *I*, with reduced diameters at the ends to fit in the circlip holes. Full compression and square extraction from the bore are necessary, since accuracy of fitting is such that the circlip cannot be withdrawn aslant.

The ball race circlip can be removed as *J*, using a screwdriver blade under one of the ends, lifting out and sideways, placing another screwdriver behind and working right round. For brake shoe pivot circlips, a blunt-ended punch or chisel, *K*, can be used for opening and freeing, and the ends of the circlip tapped with a hammer as if to drive it over the diameter. Then with the circlip loose, it is usually possible to enter a small punch or screwdriver at the back opposite the lugs, and so lever the circlip off.

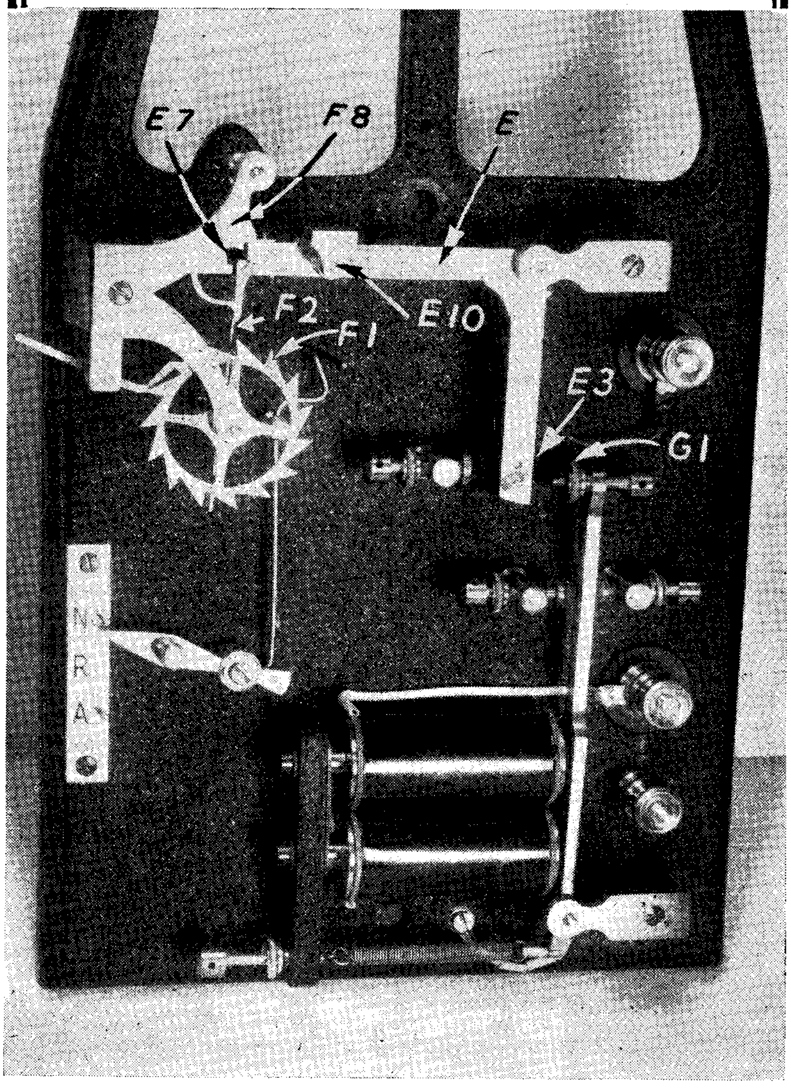
A stout circlip or locking ring on a splined shaft can prove very difficult to remove. An easy way, however, unless the material is hard, is to drill a hole from the side or above and away from the ends to weaken the circlip, *L*, until the ends can be levered open with a screwdriver or a blunt chisel used (as *K*). Careful cutting with a small chisel from the side and above will weaken a circlip.

Fitting of circlips is usually straightforward, taking care they are seating correctly, though the soft type, *D*, is best squeezed with large pliers or ordinary pincers, *M*.



Synchronome ELECTRIC CLOCKS

E. T. WESTBURY enlarges on points in a popular design of timekeeper greatly favoured by home constructors



THE SYNCHRONOME system of timekeeping, which has been in use for over half a century for the control of a number of clocks in public or office buildings, incorporates an ingenious though simple master clock or "transmitter," which has always proved attractive to amateur constructors.

An early Percival Marshall handbook *Electric Clocks and Chimes*, also its present-day successor *Electric Clocks and how to Make Them* (which incidentally was written by the inventor of the Synchronome system, the late F. Hope-Jones) contains a chapter on this transmitter and many examples of it have been constructed by readers, including some which have gained honours at M.E. exhibitions.

According to the latest reports, it seems that this clock is more popular than ever and many readers have enquired about the supply of parts for its construction, also for further information on certain details. The Synchronome Co., Abbey Works, Mount Pleasant, Alperton, Middlesex, co-operates with constructors by supplying any of the parts either in the rough or finished state. I have often consulted them on some of the points raised in technical queries and have been given facilities for examination of a standard transmitter and secondary dial movement, which has enabled detailed replies to be given.

Basic working details

It is not proposed to describe in full the principles of the Synchronome transmitter or its constructional features; most readers interested in this subject are familiar with them, or can obtain them from the book referred to earlier. The picture on this page of the electro-mechanical motion work of the transmitter and the drawing of the gravity arm explain details which have been the subject of readers' queries. The reference letters on this drawing correspond with those on the drawings published in the book.

The function of the gravity arm, *E*, is to furnish the constant force which drives the pendulum and also to close the circuit of the electromagnet which restores it to its upper position after the impulse has been given. During most of the time the arm is held up by a retaining catch, *F*8, but in the course of one revolution of the ratchet wheel, *F*1, which is driven from the pendulum by the gathering pawl, the catch is released by the vane, *F*2, attached to the arbor of the wheel and the arm is allowed to fall by its own weight, plus an extra weight attached to its extremity.

The roller, *E*10, in falling, makes contact with the curved face of the pallet, on the pendulum rod and thereby gives it an impelling impulse at or near the centre of its swing. At the end of the arm's descent, the contact, *E*3, on the end of the vertical limb touches another contact, *G*1, on the armature of the electro-magnet, which is thus energised so as to attract the armature, and through it to lift the gravity arm back on to the catch, where it is held up until the time of the next impulse, 30 sec. later.

Gravity-powered pendulum

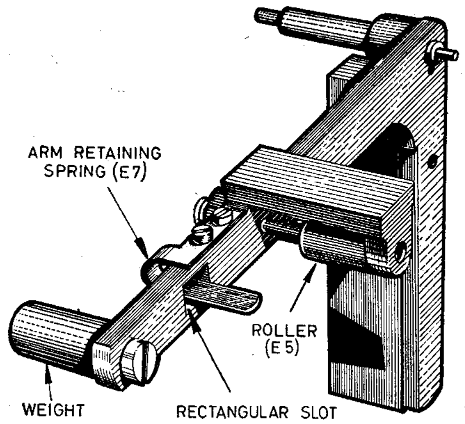
It is clear that the pendulum is not propelled directly by electro-magnetic action, but by the unvarying force of gravity, through a constant weight which is merely re-lifted by the electrical mechanism after each impulse.

The contacts also close the circuit which energises one or more secondary dials, the electro-magnets of which operate the dial motion through ratchet wheels, advancing the hands one half-minute at each impulse.

One of the times in the transmitter mechanism which is not explained as well as it might be in the book, is the method of retaining the gravity arm on the catch, and in order to illustrate this more clearly than is possible in an ordinary working drawing, a perspective sketch has been made. It will be seen that the catch is engaged, not by a rigid projection on the arm, but by the spring, *E*7, which is L-shaped in its developed or flat state—the longer arm then being bent at 180 deg.

Lower left: A close-up of the transmitter mechanism

Right: Perspective view of the gravity arm



The short portion is attached to the top surface of the arm, either by two screws, as shown, or by one screw and a dowel or steady pin, as in the earlier version of the design shown in the book.

A rectangular slot is cut in the gravity arm and the long end of the spring projects through this without touching the sides to form a detent or latch. The object of this arrangement is to avoid shock in the re-engagement of the catch when the arm is lifted. A spring of about 20 s.w.g. and of normal spring temper, is suitable.

Among other queries on this mechanism, readers have asked whether it is practicable to drive the master clock dial mechanically by a train of gears from the 15-toothed ratchet wheel instead of using an electrically-operated secondary dial.

So far as can be gathered, this method is not used by the Synchronome Co. in any of their standard movements, presumably in order to avoid making the pendulum do any more mechanical work than is absolutely necessary, but it is quite practicable, and would not affect timekeeping to a very serious extent, any more than it does on other electric impulse clocks.

Incidentally, the secondary dials controlled from the master clock are often referred to as slave clocks, but this term is definitely misleading. A slave clock, as its name implies, should *serve* its master and the proper application of the term is to the type of clock which performs the operations necessary to maintain the working of a free pendulum master clock which in its turn controls and synchronises the slave.

This arrangement is only necessary when super-precision timekeeping, as in an observatory, is required. The secondary dials, on the other hand, are not clocks in the true sense of the term, but merely repeaters or remote-controlled local indicators.

It may be added that the Synchronome master clock is not only a accurate timekeeper, but also a highly efficient electro-mechanical device, which works reliably on an extremely small current consumption. The designed standard of perfection in both respects, however, can only be attained if they are accurately made and adjusted, as described in the handbook referred to. ■

RETURN SPRINGS

on sensitive drills

CAPTAIN J. C. DAVIS makes some interesting comments on the advantages, in certain cases, of inverting the action of the return spring (or weight) on a drilling machine spindle.

While the usual method of using the spring to raise the spindle when the feed lever is released helps in backing out the drill to clear swarf, there are points in favour of using it to lower the spindle instead. For instance, when holes have to be drilled to a given depth, the limit may be set by raising the drill table, with the job in position, to the point where the spindle travel is seen by eye to be about sufficient for this depth.

Greater accuracy, if required, can be obtained by using a gauge piece between the spindle collar and the depth stop, or measurement by rule or slide gauge.

Accurate tapping of small holes, with the tap held in the drill spindle chuck, is also facilitated by maintaining positive downward pressure on the spindle. It is usually sufficient to start the tap only in this way, turning it by hand grip on the chuck, to ensure that the threads are truly perpendicular to the work; but if desired, a tap wrench can be clamped on the tap and the chuck jaws then eased off, if it is desired to continue the thread to full depth before removing the job from the machine. ■

PHOTOGRAPHIC enlarging AND enlargers

G. I. LILLEY describes the principles of construction and how to overcome problems of design

THE INCREASING POPULARITY of miniature roll-film cameras is making the process of enlarging more and more desirable. Even with the larger negative sizes projection printing is far superior to contact printing as it allows much more control to be exercised.

Sometimes it is necessary to shade a thin portion of a negative so that it does not print too darkly, and invariably the sides of a negative require cutting slightly. These processes are virtually impossible when contact printing, if a high degree of accuracy is to be attained; when projection printing, however, they are comparatively simple.

Basically, the enlarger is a projector fitted to a vertical column by means of a sliding mechanism. The baseboard or easel may be fixed, or it may incorporate a tilting device which is used for correcting a negative showing distorted perspective. The lamp house must be well-ventilated to avoid overheating and sufficiently light-tight to ensure against fogging the sensitive printing paper. To assist in providing a perfectly even field of illumination, the lamp house is fitted with a condensing lens or diffusing screen. These two systems of illumination give very different results in practice.

Condenser or diffuser ?

A condenser enlarger produces a print of much greater contrast than a diffuser enlarger, which naturally accentuates any scratches or other defects in the negative. As the light is directed, exposure times are considerably shorter. The lamp must be adjustable, for theoretically an image of the lamp filament should be formed within the projection lens, as seen in Fig. 1. As the degree of enlargement is increased so the projection lens is moved closer to the negative, making it necessary to move the lamp further away from the condenser.

In practice it is necessary to adjust the lamp only when the degree of enlargement is considerably altered, as the ideal conditions, which depend on a point source of light and optically perfect condensers, are never attained. Furthermore, the negative scatters the light to a certain extent, and it is this scattering, which is greatest in the densest areas, which increases the contrast of prints made with a condenser enlarger.

The correct position of the lamp can easily be ascertained by removing the negative carrier and examining the circle of light which is projected on to the easel. If this is bounded by a reddish zone the lamp is too far away from the condenser, but if bounded by a bluish zone the lamp is too close. If the lamp is not correctly centred this will be apparent by an unsymmetric shading of the circle.

Condensers are very often used in pairs and are obtainable complete with a suitable mounting ring. The diameter of the condenser needs to be a little greater than the diagonal of the negative.

The diffuser type enlarger is preferred by many amateurs as it possesses many advantages. Its initial cost is low, it is simple to use, scratches and graininess of the negative are less pronounced, and the disadvantage of increased exposure times is generally of little importance.

The diffuser screen should be about 2 in. distant from the negative, and its minimum dimensions may be obtained by making a scale drawing of the negative carrier and lens as they would appear at the shortest bellows extension (Fig. 2a). It must be large enough to cover fully the area of the negative as seen from the lens. It should, however, be a little larger than the size calculated to allow for the aperture, as shown in the exaggerated example in Fig. 2b.

Calculations of enlargement

The various dimensions of the enlarger depend on the largest size of negative to be used and the greatest degree of enlargement required. If 15 in. × 12 in. enlargements are likely to be made from $2\frac{1}{4}$ in. × $2\frac{1}{4}$ in. negatives, then the highest degree of enlargement required is approximately seven or eight diameters. Given the focal length of the lens, the dimensions "a" and "b" (Fig. 3) can be calculated as follows:

$$a = f\,\frac{(D + 1)}{D}$$

$$b = f\,(D + 1)$$

For $2\frac{1}{4}$ in. × $2\frac{1}{4}$ in. negatives, a suitable lens would have a focal length of about 3 in. or more. The focal length of the lens needed is equal to the diagonal of the negative; a lens of shorter focal length would not cover the negative, unless it were of the wide angle type. Now assuming

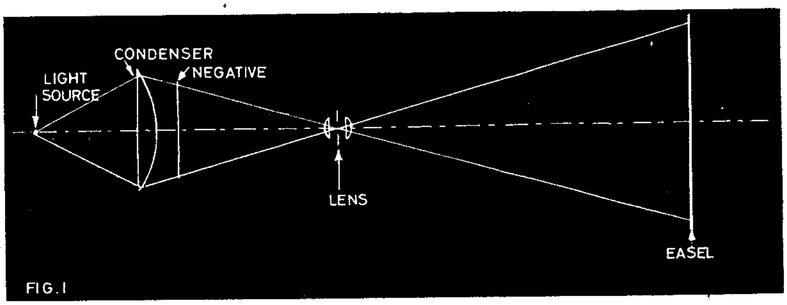


FIG. I

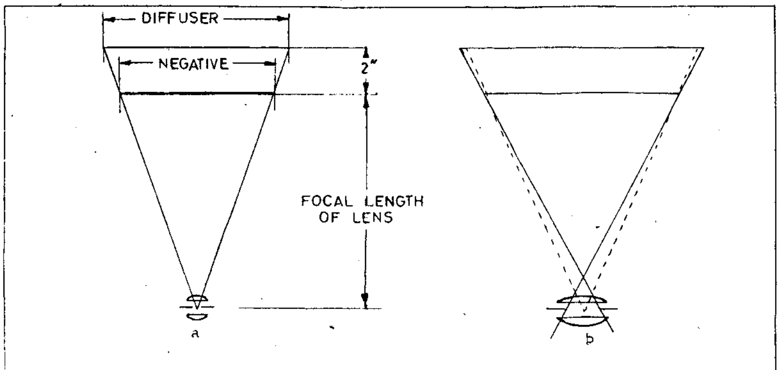


FIG 2

the maximum degree of enlargement to be seven diameters:

$$a = 3\frac{(7+1)}{7} \doteq 3\ 3/7 \text{ in.}$$

$$b = 3\,(7 + 1) = 24 \text{ in.}$$

Therefore, the total distance between negative carrier and easel would be nearly 28 in. The vertical column would need to be about 2 in. or 3 in. longer than this to allow for the width of the negative carrier housing and the pulleys over which the cables connecting the counterpoise weight to the enlarger body would run.

Interchangeable lenses

If negatives as large as half-plate ($6\frac{1}{2}$ in. × $4\frac{3}{4}$ in.) are to be used and yet provision is still required for the making of 15 in. × 12 in. prints from $2\frac{1}{4}$ in. × $2\frac{1}{4}$ in. negatives, the enlarger will be of very cumbersome dimensions unless interchangeable lenses are used, for the magnification of seven diameters from the 8 in. lens, which would be needed to cover half-plate size, would require a negative-to-easel distance of over 6 ft.

The maximum bellows extension for any enlarger is simply double the focal length of the lens to be used, as this will produce a print of the same size as the negative. If reduction is likely to be required, however, the extension must be longer. Many enlargers are not even capable of printing the same size as the negative, their smallest degree of magnification being about one and a quarter diameters.

When designing an enlarger, it should be borne in mind that another camera may possibly be bought, or even made, in the future. It is not exceedingly difficult to make a field-type camera with a long bellows extension which would be ideal for the engineer as perfect focusing could be obtained on a life-size or even larger image. Quarter-plate ($4\frac{1}{4}$ in. × $3\frac{1}{4}$ in) is a good all-round maximum size for an enlarger. It is not too bulky even when designed to produce big enlargements from small negatives and the amateur photographer is unlikely to use negatives larger than quarter-plate.

The vertical column

Most of the small enlargers on the market incorporate a tubular vertical column upon which the enlarger body slides up and down by means of a rack and pinion or friction wheel. Many of the larger models, however, are fitted with twin columns.

Probably the most satisfactory method for the home constructor is to use twin T sectional steel posts braced to the baseboard framework as shown in Fig. 3. The enlarger body may then be fitted in a variety of different ways. The chassis could be grooved down the sides or fitted with channelling, or even miniature wheels or rollers. A very simple way of fitting the latter is to mount the top pair to run behind the vertical posts and the bottom pair in front, the forward weight of the body keeping it firm.

The counterpoise weight

The enlarger body is usually balanced with a counterpoise weight, the connecting cable passing over a pulley mounted centrally on an axle at the top of the vertical posts. Two weights and pulleys could be used with a bigger enlarger or a single flat weight could be used which also would require two cables and pulleys.

It is a good plan to connect the bottoms of the counterpoise weight and enlarger body by another cable passing under a further pulley mounted at the bottom of the posts. This ensures smooth running and prevents the counterpoise weight from swaying if accidentally knocked.

The baseboard

Very often the vertical posts are not mounted direct to the baseboard but to a stout wooden frame on which the baseboard sits. This is a better system as it is essential that the baseboard is always perfectly flat. In the course of time the forward weight of the enlarger may warp the board if fixed and should it warp for any other reason it would have to be renewed.

If a tilting easel is to be incorporated, a hinged strip should be fixed along the back of the board as seen in Fig. 3, this being screwed to the base frame. The easel is then free to tilt up at the front and may be held in any position by means of a small wedge. The maximum degree of tilt required should not exceed 10 deg. to 15 deg.

Blockboard or chip-board is the best material to use for the easel. One may, of course, possess an old drawing board which would suit admirably. Any material which is firm and unlikely to warp or sag could be used.

If the enlarger body is to be made of wood, mahogany is about the best to use. It is the usual practice to bind the corners of wooden cameras and enlargers with brass, which reduces the possibility of warping. Such reinforcement also lessens the possibility of drooping of the negative carrier housing which would have to be rectified by adjusting the vertical columns.

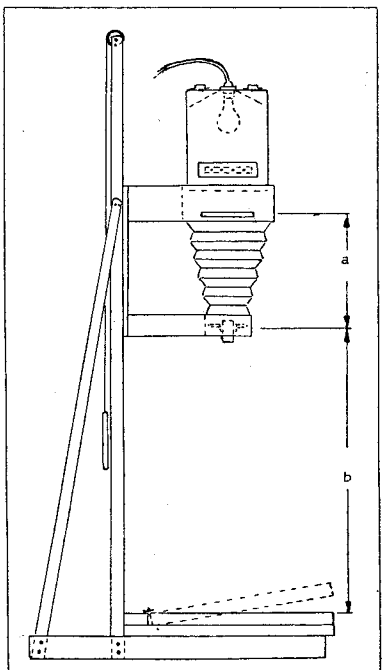


FIG 3

The body should be built out from a chassis which runs up and down the vertical posts. This chassis may consist of a frame, the top and bottom

PHOTOGRAPHIC ENLARGING AND ENLARGERS

rails of which are attached to the back surface of the styles. The rails may be let in slightly to ensure rigidity. A second frame is then fitted inside the first by means of tongues and grooves with the front surfaces of the styles of both flush.

The negative carrier housing is attached to the top of the larger frame and the lens panel housing is attached to the bottom of the inner frame as shown in Fig. 4.

The length of the chassis depends on the least degree of magnification required. The inner frame cannot be racked out too far beyond the bottom of the outer frame, for the pinion wheels must be mounted sufficiently close to the negative carrier housing to allow for the shorter extension. Therefore the longer the extension required, the longer the inner frame would have to be. While the outer frame need only be long enough to ensure the smooth sliding of the inner frame it would be wise to make it as long as the latter. This will increase the smooth running qualities of the whole chassis on the vertical columns.

Ensuring fine focusing

The racks are best mounted one either side to the face of the inner frame; if mounted in the outer frame the focusing knobs would move up and down with the lens panel, which could be rather confusing. The pinion wheels should be as small as possible to ensure fine focusing. A metal plate is provided on each side of the outer frame to take the axle on which the pinions are fitted. Now this metal plate could well be a continuation of the plate which reinforces the negative carrier housing-to-chassis joint.

All sliding wooden parts may be lubricated with paraffin wax. Oil or grease should be used very sparingly where necessary as the slightest trace picked up on a finger when printing could ruin sensitive materials.

The lens panel

The lens panel housing need not be too heavily built. It carries little weight and unnecessary bulk will only increase the possibility of sagging. About 1½ in. × ⅜ in. is a suitable size hardwood to use. This could be increased to 2 in. × ⅜ in. for a half-plate enlarger.

All that is needed for the housing is a simple frame, as seen in Fig. 4, with a slot at the front for accommodating the lens panel. U-sectioned channelling can be fitted round the inside of the housing to take the panel. It is not vitally important that the lens panel should be perfectly parallel with the negative and easel, but as it is subjected to little strain perfection should not be too difficult to attain.

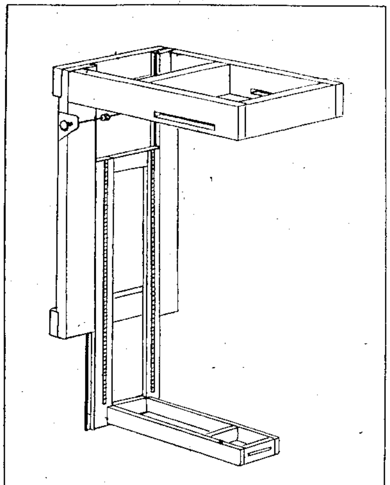


FIG 4

A reasonably good second-hand lens costs upwards of £4 or £5. When the lens is bought it should be complete with flange. A circular hole is cut in the centre of the lens panel over which the flange is screwed. The lens itself may then be screwed in.

If interchangeable lenses are to be used, another lens panel will be needed. When cutting the slot in the front of the lens panel, housing allowance must be made for the thickness of the flange. The little gap thus made will not matter, but for the sake of appearance a thin strip of wood can be attached to the front edge of the lens panel so as to plug it when the panel is in place.

A rebate will be required round the top inside edge of the lens panel housing to take the bottom end of the bellows.

The negative carrier

The negative carrier housing needs to be very sturdy. Not only must it bear the weight of the lamp house and diffuser, but it will also be subjected to a lot of wear and tear, for in use the negative carrier is continually being pulled out and replaced. It should be made about 3 in. deep and if made of wood, ½ in. thick material should provide enough rigidity. All corners and joints will, of course, be bound with metal. If the negative carrier is accommodated near the bottom edge, the diffusing screen, which should be a loose fit inside the housing, can rest on a ledge about ½ in. from the top. The lamp house can then stand in a groove cut round the top edge of the housing, as seen in Fig. 5. A rebate will be required round the inside of the bottom edge to take the top end of the bellows.

It is desirable that the negative carrier should slide right through the housing from one side to the other; therefore, a slot must be cut through each side, and channelling fitted inside the housing to guide the carrier through. Any inside spaces between the channels and the front and back of the housing must be blocked to prevent light from the diffuser reaching the lens.

The negative carrier is a simple frame rebated on the inside to take a piece of plate glass a fraction larger than the negative size. In use the negative is placed, emulsion side down, on to the plate glass and is held in position by another piece of glass.

Focusing screen

A useful device is the focusing screen, and provision can be made for this by making the aperture in the negative carrier about 2 in. longer than the negative. In this space is fitted an old scratched negative. Focusing can be adjusted far more easily on the image of these scratches than on that of the average negative.

If negatives smaller than the aperture in the carrier are to be used a mask is necessary to cover the clear glass. While this could effectively be

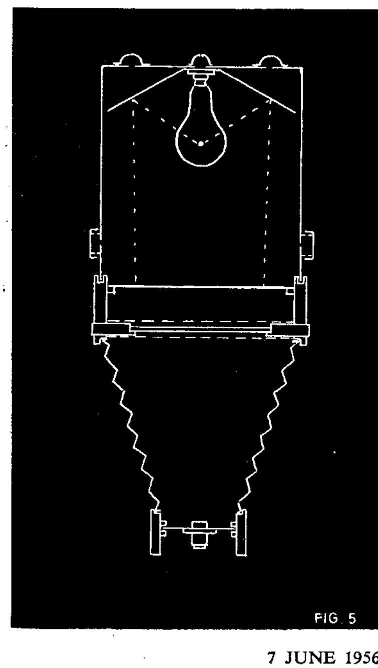


FIG 5

made of black paper it is better to make it of tin foil or some similar substance which reflects the light and heat instead of absorbing it. If a mask is not used the result will be a considerable loss of contrast owing to a slight overall fogging of the sensitive paper which is caused by reflection of the light within the lens. Each air-to-glass surface of an ordinary lens reflects about 5 per cent. of the light falling upon it, and many lenses have at least three components.

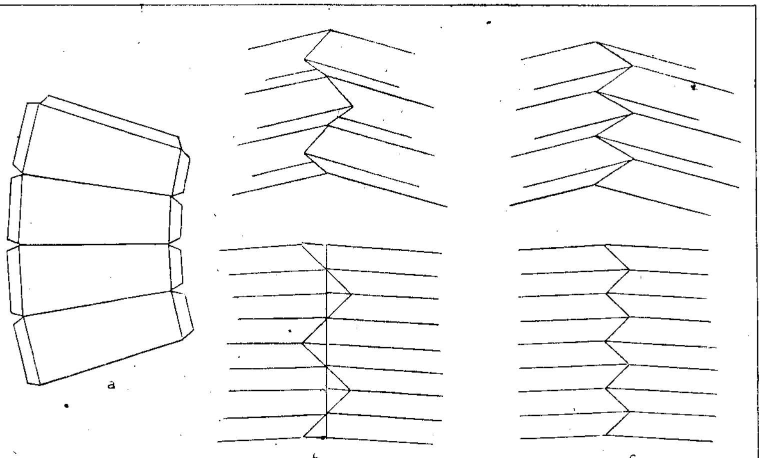


FIG 6

Flashed opal glass is the most suitable material to use for the diffuser. Ground glass can be used, especially if the light source is to be of the mercury vapour type which provides a fairly flat field of illumination, but its diffusing powers are far below those of opal glass.

All inside surfaces below the diffusing screen should be finished matt black to prevent reflection.

The bellows

The bellows are made of a light-proof black fabric. A good quality leather-cloth suits quite well.

Professionally made bellows are often reinforced down the sides for extra stiffness, the corners being left plain as they need to be fairly supple. Such stiffening is hardly necessary with small bellows, however, providing fairly stout cloth is used.

The cloth for small bellows can be cut out in one piece (Fig. 6a). Larger bellows, however, are usually made in sections. Each segment of the cut-out pattern is of rhomboid shape, the wide end being as long as the negative carrier housing rebates and the short end as long as the lens panel housing rebates, the perpendicular height being a little more than the longest bellows extension required. An extra inch should be allowed all round for joining.

Great care must be taken to see that each of the four segments is perfectly regular in shape, otherwise when the blank is folded up a kink will be formed which will prevent the bellows from collapsing neatly.

There are two ways of folding the bellows at the corners, as shown in Fig. 6. Type *C* is more popular and is the better of the two because there are less double folded corners per section.

Fig. 6 shows the approximate position of the folds, which should be roughly folded in before the seams are cemented together. When the cement is dry, if the folds are given a start, the bellows can be squeezed down and the corners will find their own way home. The tabs at the top and bottom may then be folded in such a way as to permit neat fixing in the rebates.

The design of the lamp house and the finish of its inside surfaces have a great influence on securing an even field of illumination. It needs to be fairly light in weight, an aluminium alloy being one of the best materials to use.

The ordinary tungsten filament lamp is the most convenient type to use. There are special enlarger lamps on the market which are rated at about 150 watt but give a light output equal to a 400 watt lamp, their life being in the region of 100 hours. These are ideal and as they are the same size as a normal 60 watt lamp, the lamp-house can be of modest proportions.

The easiest and possibly neatest way of making the lamp-house is first to make a simple square box, afterwards fitting a reflector inside. Ventilation holes can then be drilled in the sides and top, these being covered with suitable light-traps.

The height of the lamp-house must be sufficient to allow the lamp filament to be at least 6 in. or 7 in. above the diffuser. An enlarger of half-plate size is best fitted with two lamps.

The reflector can be of conical or pyramid shape. The latter is simpler and quite efficient. The angle of the reflecting surfaces is important and must be calculated to reflect the light towards the edges of the diffuser. This can easily be done by making a scale drawing of the lamp and diffuser. The principle can be seen in Fig. 5.

The light traps which cover the ventilation holes may be made in any way which will necessitate a double reflection of light before it can escape. If the inside surfaces are then painted matt black the light will be satisfactorily absorbed.

If an inside reflector is incorporated in the lamp house all surfaces above the reflector may be black, thus simplifying the top ventilation hole covers.

All reflecting surfaces in the lamp house should be finished matt white to assist in diffusing.

A switch must be provided in some convenient place for making exposures. Many photographic workers prefer a foot switch as it leaves both hands free for shading and other manipulations.

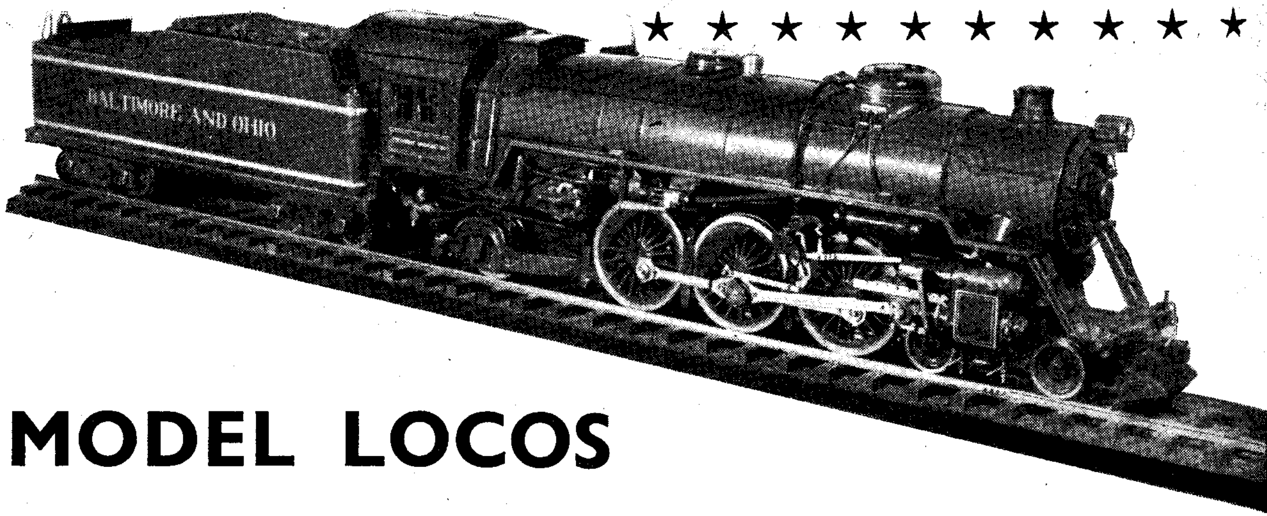
When completed, the enlarger should always be covered with a dust sheet, as perfect cleanliness is essential in all photographic work. Dust is one of the photographer's greatest enemies. ▣

SUNKEN LOCOMOTIVES

A group of Auckland aqualung divers recently examined the wreckage of S.S. *Wiltshire*, wrecked in Rosalie Bay near the Great Barrier Island in 1922. The ship was too badly damaged to allow a close examination, but somewhere in her hold are two brand-new locomotives that never ran on the rails.

They are two Ab-class 4-6-2 locomotives built by the North British Locomotive Co. for service in New Zealand and their numbers, 732 and 762, were allocated to replacement engines built the following year.

This is not an unusual fate for sea-borne locomotives, as there are many cases of engines being dropped in the sea—usually when they are being unloaded. I cannot recall any reports of locomotives being salvaged but I would be most interested of any.—VULCAN.

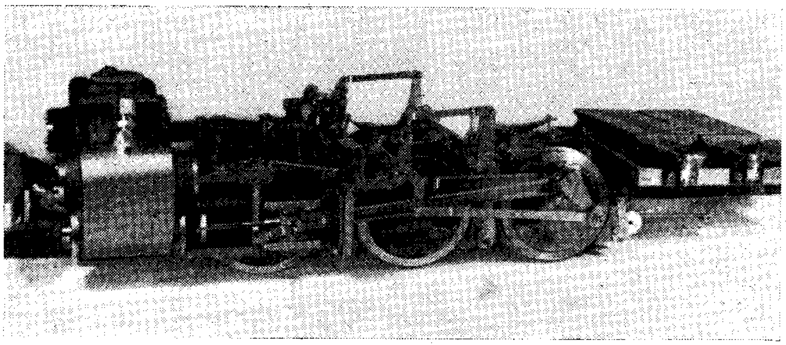


MODEL LOCOS

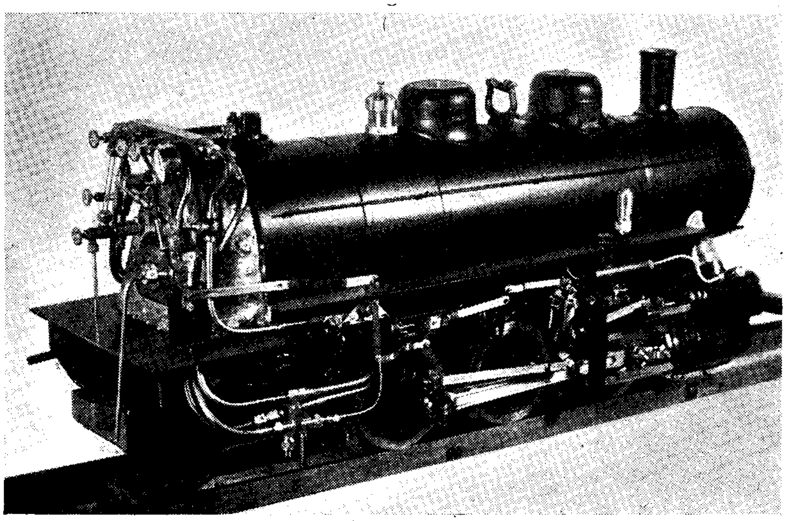
. . . on the Other Side

Writing from Baltimore H. J. COVENTRY draws attention to some model-making advantages of American engines, singling out a 'B. & O.' locomotive for this purpose

$\frac{3}{4}$ in. scale President Washington, Baltimore & Ohio Railroad, first built 1927. Cylinders $1\frac{3}{8}$ in. × $1\frac{3}{4}$ in. stroke; wheels 5 in. dia.; boiler barrel 5 in. dia.; weight with tender 140 lb.



$\frac{3}{4}$ in. scale B. & O. six-wheel switcher in course of construction. Cylinders $1\frac{1}{8}$ in. bore × $1\frac{3}{4}$ in. stroke; wheels $3\frac{5}{16}$ in. dia.; Baker valve gear



B. & O. $\frac{3}{4}$ in. scale D.30 class switcher in course of construction

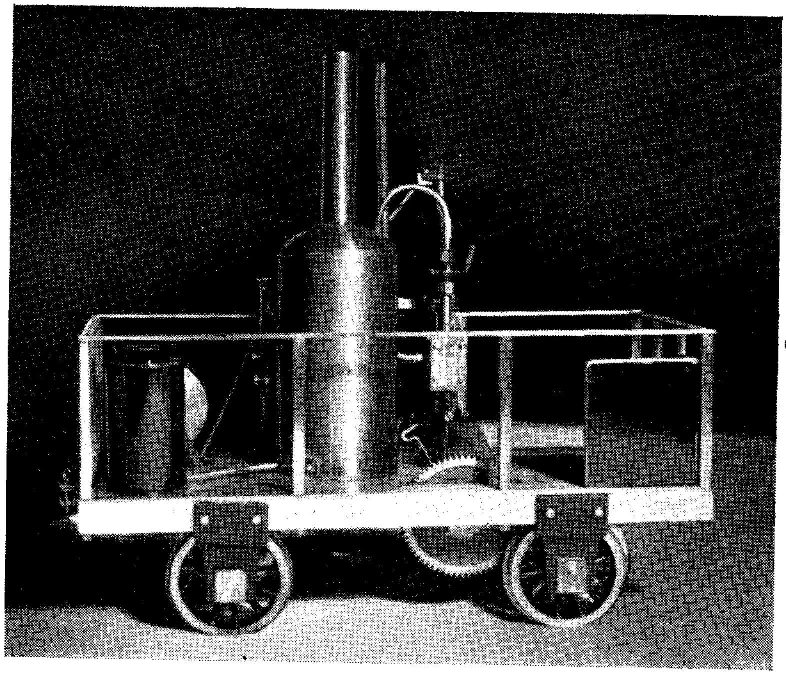
★ According to letters in recent issues of the Model Engineer there seems to be quite an amount of interest in American locomotives.

For model purposes the engines of the United States offer quite an assortment of types and sizes and, possibly, a few advantages over British prototypes. Although rail gauge is the standard 4 ft. 8½ in. the loading gauge is much greater, being an average of 10 ft. wide by 15 ft. high—some western roads as high as 15 ft. 10 in. Roughly, the American model would be one size larger than the British for the same scale. A ¾ in. scale would weigh from 100 to 200 lb. for a late type, hence quite powerful engines can be made. Among the disadvantages are the heavier parts and available shop equipment to handle them.

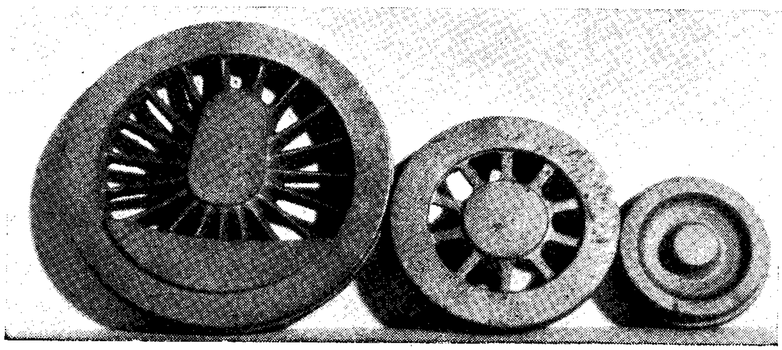
Wide use of steel castings

The American locomotive design makes use of steel castings to a large extent, many of the latter types having castings of such complicated shapes and cores that it is almost impossible to model them by any other means than making patterns for the model.

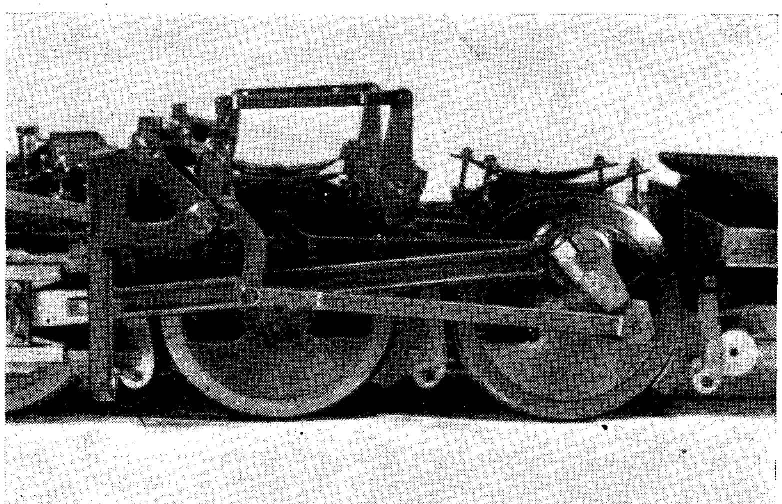
The Class I locomotive of the Baltimore & Ohio Railroad built in 1895, is a 4-4-0 type with a large firebox and outside cylinders with slide valves; it should make a good working model. I have official drawings of this engine from which to draw up detail and assembly plans. Incidentally there are over 30 sheets, 34 × 22, covering the switcher, so one may judge there is a great deal of preliminary work to an American engine. ▣



¾ in. scale "Tom Thumb" of 1829, the first passenger hauling locomotive in the United States (not a successful model as the boiler is too small)



¾ in. B. & O. P.7 grey iron rough castings



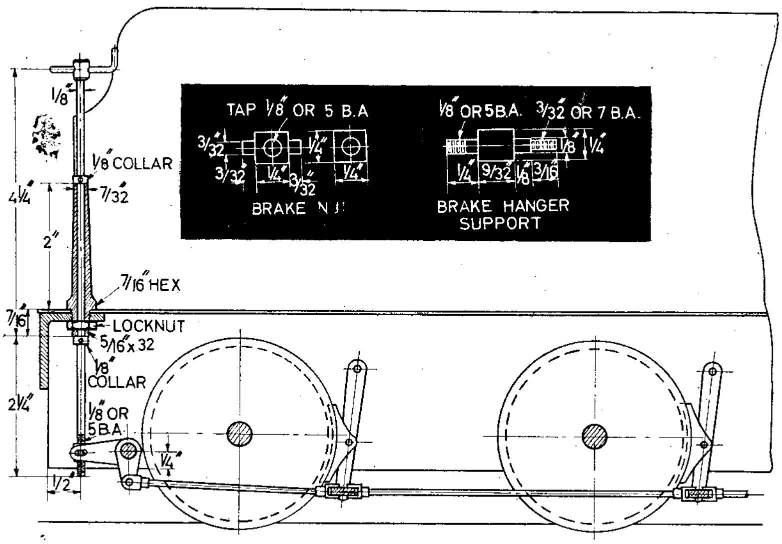
¾ in. B. & O. 30 class six-wheel switcher showing Baker valve gear

TENDER BRAKE GEAR

Although the brakes on a $3\frac{1}{2}$ in. gauge tender are not powerful enough for service use, their inclusion adds realism

IN DAYS GONE BY I was often amused by descriptions of elaborate brake gear fitted to locomotives which could hardly keep going with no load at all behind the tender. It seemed to me that designers and builders should have made certain that the engine could go before providing means of stopping it!

Anyway, as *Ivy Hall* will be able to do everything needed in the way of "going," builders can go ahead and fit the tender brakes with easy conscience. It is a simple job, rendered easy by the absence of any power-operating device; when the fireman's handle is turned clockwise, the brake nut rises, pulls up the actuating arm, and the lower end of the drop arm moves forward, pulls the rods and beams, pressing the brake blocks against the wheel treads.



Arrangement of brake gear and, above, the brake nut and brake hanger support

Brake column

The brake column is made from a $2\frac{1}{2}$ in. length of $\frac{7}{16}$ in. hexagon brass rod. Chuck in three-jaw, face the end, centre, and drill right through with a No. 30 drill; if your drill is not long enough, drill as deeply as you can. Turn down $\frac{7}{16}$ in. of the end to $\frac{5}{16}$ in. dia. and screw $\frac{5}{16}$ in. × 32. Rechuck the other way around in a tapped bush held in the three-jaw. If the drill has not gone through, centre the other end and drill down from that end until the drill meets the first hole. Take a very light skim off the end to true it up.

Bring up the lathe tailstock to support the work while the taper is being turned, entering the point in the hole; then, using a roundnose tool, and with the topslide set over about one degree, turn the outside as shown, leaving about $\frac{1}{8}$ in. at the bottom, the full size of the hexagon. Make a locknut from the $\frac{7}{16}$ in. hexagon rod tapped to fit the spigot at the bottom of the column.

The spindle is a $6\frac{1}{2}$ in. length of $\frac{1}{8}$ in. round steel; either mild or silver will do. Grip in the three-jaw and put about $\frac{3}{8}$ in. of $\frac{1}{8}$ in. or a 5 B.A. thread on one end. The other end is furnished with a cross-handle made and fitted exactly the same as that on the end of the injector water-valve, so repetition is not needed for that job.

Chuck a piece of $\frac{1}{4}$ in. rod in the three-jaw, face, centre, drill down about $\frac{1}{2}$ in. with a No. 32 drill and part off two slices a full $\frac{1}{8}$ in. thick. Drive one on the spindle until it is about $1\frac{3}{8}$ in. below the handle, push the spindle through the column and then drive on the other collar. Adjust this until there is exactly $2\frac{1}{4}$ in. of spindle projecting below the column then pin the collar to the spindle. Bring down the upper collar until it just touches the column but still leaves the spindle quite free to turn; then pin that collar as well and the brake column is complete.

The brake shaft requires a 5 in. length of $\frac{1}{4}$ in. round mild steel. Chuck in the three-jaw and turn down $\frac{9}{16}$ in. of the end to $\frac{3}{16}$ in. dia. slightly rounding it off with a file. Reverse in the chuck and turn the other end to the same diameter for $\frac{3}{8}$ in. length. For the bearings, chuck a piece of $\frac{1}{2}$ in. hexagon rod in the three-jaw, face, centre, and drill $\frac{3}{16}$ in. for $\frac{1}{2}$ in. depth. Turn down $\frac{1}{4}$ in. of the outside to $\frac{3}{8}$ in. dia. and screw $\frac{3}{8}$ in. × 32. Part off at a full $\frac{1}{8}$ in. from the shoulder, reverse in chuck and chamfer the corners of the hexagon.

The drop arm is filed up from $\frac{3}{8}$ in. × $\frac{1}{8}$ in. mild steel to the shape shown; the smaller end is drilled No. 30 and the larger end first drilled 15/64 in. and then opened out with the "lead" end of a $\frac{1}{4}$ in. parallel reamer until the arm will drive on to the shaft. Set it exactly in the middle.

Actuating arm

The actuating arm is made in two pieces in order to get the brake nut between. Each half is filed up from $\frac{3}{8}$ in. × 3/32 in. mild steel, or offcuts from the frame steel will do nicely. To form the slot drill two No. 41 holes, just touching, and run into one hole with a rat-tail file. The large ends are drilled No. 14 which should be a drive fit for the reduced end of the brake shaft.

To bend, grip the larger end in the

bench vice with about 3/8 in. projecting and bend over with a big pair of pliers or a hand vice to about 45 deg. Then grip the bent part at 3/8 in. from the end with the pliers or vice and bend toward the middle again. This will form the reverse bend; when placed together, the jaw should just admit a piece of 1/4 in. square rod.

To make the brake nut, chuck a piece of 1/4 in. square bronze or gunmetal rod truly in the four-jaw. Face off and turn a 3/32 in. pip on the end 3/32 in. long. Part off at a bare 3/8 in. from the shoulder, reverse in chuck, and repeat the operation on the other end leaving a 1/4 in. cube between the pips or trunnions. Centre this, drill No. 40, and tap to suit thread on the brake spindle. Next, put one of the halves of the actuating arm on the longer reduced end of brake shaft then add the other half with the brake nut between, the trunnions fitting in the slots in the arm. Set the arm at right angles to the drop arm and braze or silver-solder both to the shaft.

Erecting shaft and column

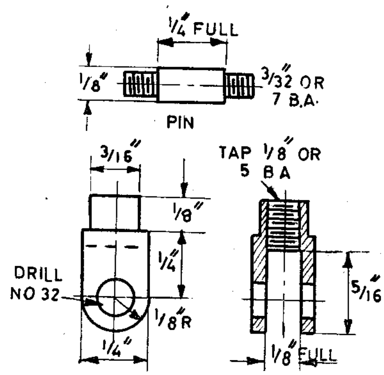
At 2 in. from centre-line of tender—to your left when looking at the front end of it—and 5/8 in. from the front edge of the drag beam, drill a 9/32 in. hole and tap it 5/16 in. × 32, the hole going right through the soleplate and the top of the beam. At the bottom of the frame, at each side, 1 1/4 in. from the front end and 1/4 in. from bottom edge, drill an 11/32 in. hole and tap it 3/8 in. × 32. Put the brake shaft in place between the frames, with the reduced ends through these holes, which is easily done if the end farthest from the actuating arm is entered first. Then screw the bearings in place in the tapped holes in frame, the ends of the shaft entering the bearings as shown in the plan.

Insert the lower end of the brake spindle through the hole in the top of drag beam and screw through, putting on the locknut, and at the same time guiding the threaded end of the spindle into the brake nut. Wind this up a little way then tighten up the brake column and the locknut. The column should then be quite firmly held and if the handle is turned the nut should move up and down the spindle without binding.

Brake blocks and hangers

Cast-iron brake blocks should be available as these are standard for any 3 1/2 in. gauge tender; and they should only need cleaning up with a file, the hanger slot cleaned out, and the holes drilled for the pins. Failing castings, the blocks can be made from mild steel of 1/4 in. × 5/8 in. section in the manner described for the engine's brake blocks.

The hangers can be filed up from 5/16 in. × 1/8 in. steel strip. Note that one side is straight, but the side to which the block is attached is relieved slightly to allow the block free movement to bed itself to the wheel tread. Drill holes as shown then put the hanger into the slot in the brake block and pin with a piece of 3/32 in. silver-steel which should be a drive fit in the holes in the block, clearing

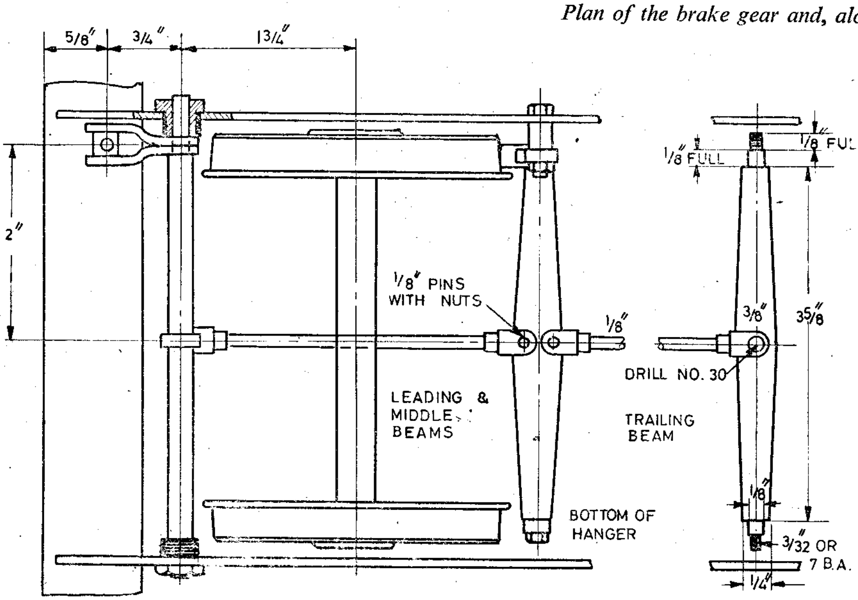


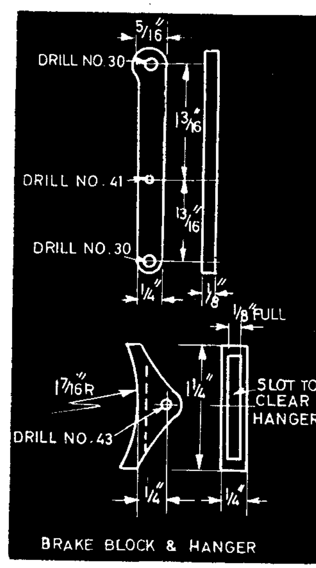
The pull-rod forks

in the hanger. The blocks should be easy enough to move on the hangers and adjust themselves to the wheel treads when the brake is applied, but not easy enough to flop about and rub against the wheels when the brake is off.

To make the supports, chuck a piece of 1/2 in. round steel in the three-jaw, face the end and turn down 1/4 in. length to 1/8 in. dia., screwing 1/8 in. or 5 B.A. Part off at a bare 5/8 in. from shoulder; reverse in chuck, turn down 5/16 in. full to 1/8 in. dia., further reduce 3/16 in. length to 3/32 in. dia. and screw 3/32 in. or 7 B.A. The longer ends go through the holes in the tops of the hangers, which fit on to the 1/8 in. plain part, and are secured by 3/32 in. or 7 B.A. nuts. The other ends go through the holes in the frame and are fixed by nuts outside the frames which are shown in the

Plan of the brake gear and, alongside, the brake block and hanger





L.B.S.C.'s IVY HALL

general arrangement drawing just to the right of the spring hangers.

The leading and middle brake beams are filed or milled to shape from ½ in. × ⅛ in. mild steel. Each needs a piece 4¼ in. long. Chuck truly in the four-jaw, face off, turn a full ¼ in. length to ⅛ in. dia. and further reduce another full ⅛ in. to 3/32 in. dia., screwing 3/32 in. or 7 B.A. Reverse in chuck and repeat the operation; for beginners' benefit I will repeat that if Nos. 1 and 2 jaws are slacked to remove the work and the same two tightened again after reversing the work will still run truly.

Erection and adjustment

Drill two No. 30 holes a full ¼ in. apart on the middle line of the beam. The trailing beam can then be made in the same way, using steel only ⅜ in. wide, one hole only being needed in the middle, as shown in the plan drawing. The forks, or clevises, as American railroadmen sometimes call them, are made from ¼ in. square steel in exactly the same way as valve gear forks, but to the dimensions shown. Six are needed.

First place a fork at each side of the leading and trailing beams, as shown in plan, and fix them with little bolts made from ⅛ in. silver-steel, nutted at both ends, as described for bolts in the valve gear. Next, fit one only to the trailing beam. All three beams can then be placed between the bottoms of the hangers; if there should be difficulty in springing the hangers outward to get the second end of the beam through the hole at the bottom slack the screw holding the hanger support to the frame.

Finding length of pullrods

Use ordinary commercial nuts on the screwed ends of the beams to retain the hangers in position. Temporarily attach the remaining fork to the bottom of the drop arm. Now turn the tender upside down on the bench, with the actuating arm on the brake shaft horizontal. Press the brake blocks against the wheels and, keeping them in that position, measure the distance between the bosses of the forks attached to the beams and the drop arm.

Add 5/16 in. to the dimensions indicated and you have the exact length of the pull rods. These are cut from ⅛ in. round steel and each should be screwed at both ends for a full ⅛ in. length, either ⅛ in. or 5 B.A. to suit the tapped bosses of the forks. Remove forks, screw them on to the pull rods, and replace.

When the brake handle is turned to bring the actuating arm just a little above the horizontal, the blocks should bear evenly against the wheel treads. All six should touch the treads at the same time; if one pair of wheels locks tight and one pair will spin it is just a matter of taking out the fork bolt and turning the fork to adjust the length of pull rod. When all six bear evenly, tighten up all the bolts and the job is finished. Give all the joints a spot of oil.

It will be seen that no compensating gear is specified. It is not needed, as the brakes are useless for service stops as I have pointed out before; and as long as they operate and can be used for "parking" they serve their purpose. As a matter of fact the tender brakes on the old L.B. & S.C.R. engines of my footplate days had no compensating gear but they worked perfectly satisfactory. Sometimes when a new set of cast-iron blocks were fitted they did not all bear on the wheel treads with the same pressure, but after the first trip they would bed down, especially on the goods engines.

Some of the older goods engines had wooden brake blocks and it would be a source of surprise to the uninitiated to know how long these wooden blocks lasted. Many of the older drivers preferred them, declaring that they gripped better in wet weather, and of course they had far less wearing effect on the wheel treads than those made from cast-iron. The latter were not machined in any way; merely being drilled for the pins and erected on the hangers.

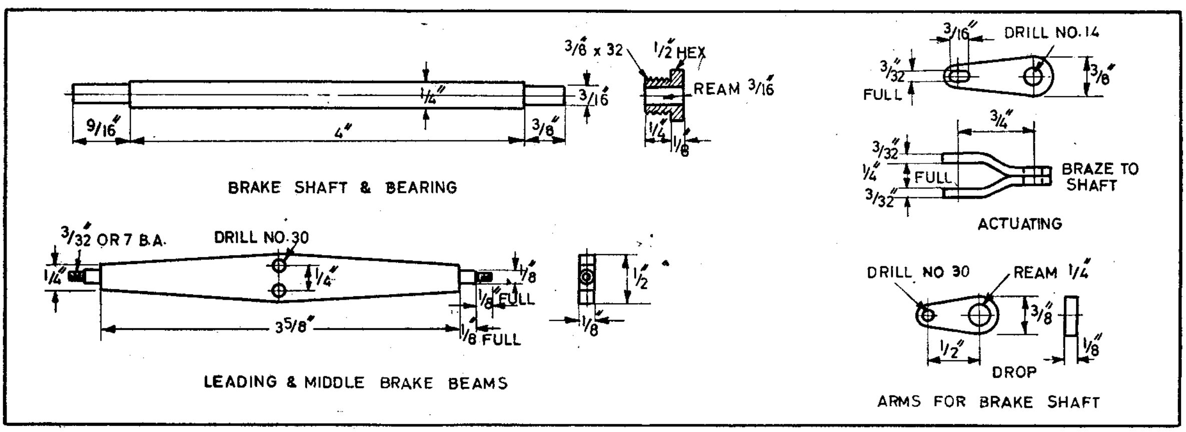
Compensated brakes

Many modern locomotives have uncompensated brakes and have no trouble in stopping, the blocks wearing themselves in, as stated above, after a run or two. The automatic brakes on the coaches are automatically compensated, owing to the coaches being on bogies; a different proposition to locomotives with part of the wheelbase rigid.

I use compensated brake gear on the passenger cars on my own line, which are all bogie stock; and incidentally I have found by experiment, after trying steel, cast iron, bronze and other metals for brake blocks, that the best material to use for them is red fibre. This gives a good grip, does not wear the treads of the wheels, and is long lasting; a flashback to the behaviour of their full-size hardwood cousins of the "Brighton Line" of fifty years ago!

(● *To be concluded next week*)

The tender brake gear showing, top left, brake shaft and bearing; below, left, the leading and middle brake beams; and, right, the arms for the brake shaft



ELECTRICAL DESIGN SIMPLIFIED by J. Gordon Hall

PART TWO

Magnetic effects

The effects of different types of electro-magnets and the basic laws which govern their construction are dealt with here

THE PREVIOUS ARTICLE dealt with the laws governing the flow of electric currents through conductors and the effects produced thereby. Readers will be chiefly interested in the magnetic effects and how they may be utilised.

Leaving for the moment rotary apparatus such as dynamos and motors, relays and similar apparatus used largely for remote and radio control depend for their action on electro-magnets employing an iron core surrounded by an energising coil carrying current and attracting an iron armature through an air gap. The strength of pull depends upon the total number of lines of force established round the magnetic circuit consisting of the core, the air gap or gaps and the armature.

The strength of such magnetic flux, that is, the number of lines of force per sq. in. of air gap, depends upon the number of ampere turns comprising the energising coil; that is, the number of turns multiplied by the current in amps flowing therethrough; this is the magneto-motive force.

For the class of apparatus we have under consideration a suitable flux density in the air gap would be from 20,000 to 30,000 lines per sq. in.; it would not be advantageous to exceed this figure in small apparatus of amateur construction.

Table 8 gives the approximate pull which may be anticipated with different areas of air gap at three different flux densities. For convenience the equivalent dimensions of standard round, square and flat strip-iron sections are given.

From this table the appropriate section of iron may be chosen for the required pull. No useful purpose would be served by giving the exact theoretical figures for the values of pull so they have been cleaned up to the nearest lower ¼ oz. for the smaller sections and the nearest lower ¼ lb. for the larger.

Table 10 gives the approximate number of amp-turns required to establish these flux densities across air gaps of various lengths and it should be understood that these figures apply irrespective of the size of the core. For example, the same number of amp-turns would be required to establish a flux density of 20,000 lines per sq. in. across an air gap $\frac{1}{16}$ in. in length and ½ sq. in. in area as for an air gap the same length but 1 sq. in. area.

The space occupied by these amp-turns will of course depend upon the current density in amps per sq. in. at which we load the wire and for present purposes we may take 4,000 amps per sq. in. of copper as a suitable figure under normal working conditions of temperature and ventilation.

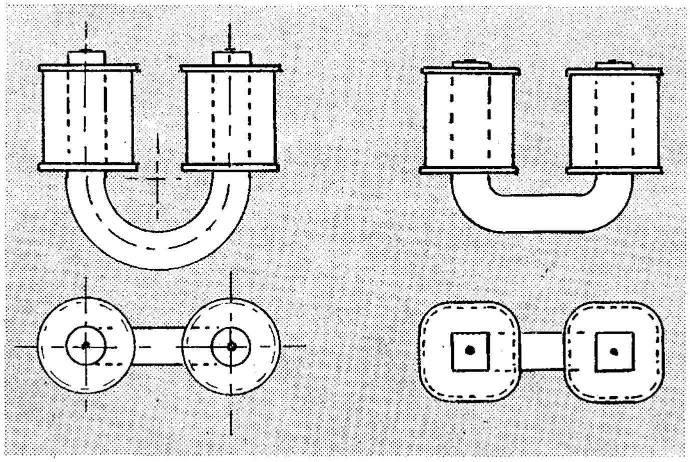
Right, Table 8: The approximate pulls across various air gaps are shown here

Approx. Pull Across Air-gap to Nearest (Lower) ¼ oz. or ¼ lb.						
Core Section				At Lines per sq. in.		
● dia. in.	■ sq. side in.	▬ in.	Area sq. in.	20,000	24,000	30,000
⅛	—	—	0.0123	1 oz.	1½ oz.	2¼ oz.
—	⅛	1/16 x ¼	0.0156	1¼ oz.	2 oz.	3 oz.
3/16	—	—	0.0276	2¼ oz.	3¾ oz.	5¼ oz.
—	3/16	3/32 x ⅜	0.0351	3 oz.	4¾ oz.	6¾ oz.
¼	—	—	0.0491	4¼ oz.	6½ oz.	9¾ oz.
—	¼	⅛ x ½	0.0625	5½ oz.	8½ oz.	12½ oz.
⅜	—	—	0.1105	9½ oz.	15 oz.	1¼ lb.
—	⅜	¼ x ⅝*	0.1406	12¼ oz.	1 lb.	1¾ lb.
½	—	—	0.1964	1 lb.	1½ lb.	2¼ lb.
—	½	¼ x 1	0.250	1¼ lb.	2 lb.	3 lb.
¾	—	—	0.4418	2¼ lb.	3¾ lb.	5½ lb.
—	¾	½ x 1⅛	0.5625	3 lb.	4¾ lb.	7 lb.
1	—	—	0.7854	4¼ lb.	6½ lb.	9¾ lb.
—	1	½ x 2	1.0	5½ lb.	8½ lb.	12¼ lb.

* 0.1562

Below, Table 9: Details of wire resistances and gauges

S.W.G.	Res. per 1000 yd.	Amps at 1000/sq. in.	Turns/Inch Length: Enamel	S. Silk & Enam.	D.C.C.
18	13.267	1.810	20	19	17
20	23.59	1.018	26	24	21
22	38.99	0.6158	33	31	26
24	63.16	0.3801	42	40	32
26	94.35	0.2545	51	48	37
28	139.55	0.1720	62	58	42
30	198.80	0.1208	75	68	46
32	262.1	0.0916	85	76	50
34	361.2	0.0665	100	88	54
36	529.2	0.0454	119	103	64
38	849.1	0.0283	149	125	71
40	1326.7	0.0181	188	151	78
42	1910.5	0.0126	222	175	—
44	2985.0	0.0080	277	208	—



Above, Figs. 11 *and* 12, *and below, Figs.* 13 *and* 14: *With the exception of laminations these are the most efficient forms of core*

Approx. Amp-Turns Required for Air Gaps			
Length of Gap ins.	Amp-Turns at Lines per sq. in.		
	20,000	25,000	30,000
1/32	196	245	294
1/16	392	490	588
3/32	588	735	882
1/8	784	980	1,176
5/32	980	1,125	1,470
3/16	1,176	1,470	1,760
1/4	1,568	1,960	2,352
5/16	1,960	2,450	2,940
3/8	2,352	2,940	3,528
1/2	3,136	3,920	4,704

Above, Table 10: *This gives the number of amp-turns required to span air gaps of various sizes*

Since by far the greater number of amp-turns will be required to overcome the air gap or gaps it is in order initially to ignore the amp-turns required for the iron components of the circuit.

Having decided the number of amp-turns required and the current density at which they are to operate, the cross-sectional area of copper required may be ascertained by regarding the coil as consisting of a single turn of copper carrying a current in amps equal to the number of amp-turns.

" Space factor "

For example, if 8,000 amp-turns are required at the suggested current density (4,000 per sq. in.) the area of copper required would be $\frac{8,000}{4,000} = 2$ sq. in. However, the coil will consist of turns of wire in layers and space will be taken up by insulation and waste space between turns and layers and a suitable " space factor " would be 2.

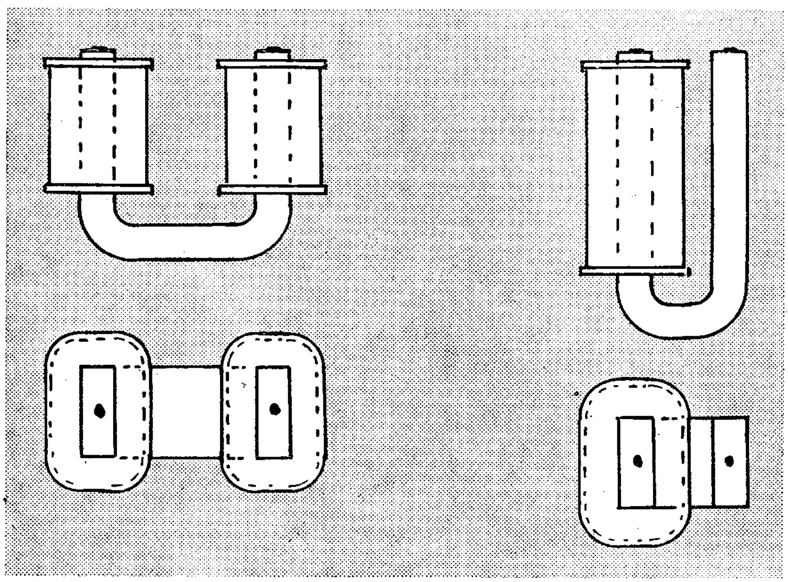
In addition to the space factor, allowance must be made for leakage lines and a factor of not less than 1.3 must be taken: thus, taking the example given above of 8,000 amp-turns, the cross-sectional area of the coil would be $\frac{8,000}{4,000} \times 2 \times 1.3 = 5.2$ sq. in., say $5\frac{1}{4}$. The shape of the core will almost invariably be round, square or flat strip and the proportion, depth of layers to length of coil, is important.

The outside diameter of the coil should not exceed three times the diameter of the core; if square, three times the length of side; and if flat strip, three times the length of the shorter side. The length of the coil should be not less than three times the depth of the layers; within reason the longer the coil the more efficient.

From these figures the dimension of the coil or coils may be planned and the approximate length of a " mean turn " that is, one turn situated in the middle layer, may be estimated, this of course, representing the average length of the turns.

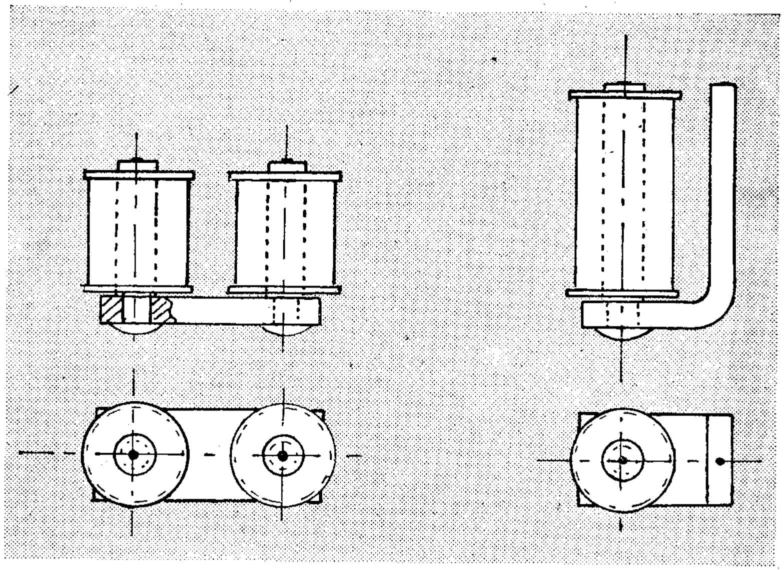
Assuming that the voltage at which the apparatus is to work has been decided the resistance of the mean turn will be $r_m = \frac{volts}{No.\ of\ amp\text{-}turns}$, and since we know the length of a mean turn we can calculate the resistance per thousand yards.

From the wire tables a gauge of wire can be chosen with a resistance per thousand yards as near as possible to this, and from the same table we can find the number of turns per in. for that gauge of wire and thus the number of turns which will go into the coil space.



Multiplying the number of turns by the length of one mean turn we get the total length of wire in the coil, and from the table we find the resistance of this length. By Ohms law ($C = \frac{E}{R}$) the current in amps which will pass at the selected voltage may be calculated. Multiplying this current by the number of turns gives us the approximate number of amp-turns.

It is probable that the figure will work out at a greater number of amp-turns than we require. If this is the case the extra amp-turns will do no harm, but if this figure is too low the length of the coil may be increased, more turns added and, if necessary, a different gauge of wire tried; but the current density must not greatly exceed 4,000 amps per sq. in.



Figs. 15 and 16: These show a core formed of flat strip and round rod

Practical design of electro-magnets

Since many readers are at this time interested in the design of relays and similar devices for remote and radio control the writer has thought that a few hints on the practical design of such devices might be welcome at this point.

The basis of all such apparatus is an electro-magnet attracting an armature through an air gap, and it should be noted that it is the initial pull when the air gap is at a maximum length, which is important, and it is upon this that the calculations above are based. For the moment we are considering apparatus operated by continuous or direct current only and not alternating current.

Before commencing the design three factors must be decided: (a) the voltage at which the apparatus is to work, (b) the initial pull required, (c) the length of air gap. If there are two or more air gaps the effective length is their sum; the effective area is the area of one gap.

Neglecting for a moment laminations, the most efficient form of core is that shown in Fig. 11 and next in efficiency those shown in Figs. 12, 13 and 14, all being formed of a piece of iron bent to shape with no magnetic joints. Figs. 15 and 16 show a core formed of flat strip and round rod which should be shouldered down and driven tightly into a reamed hole in the flat strip.

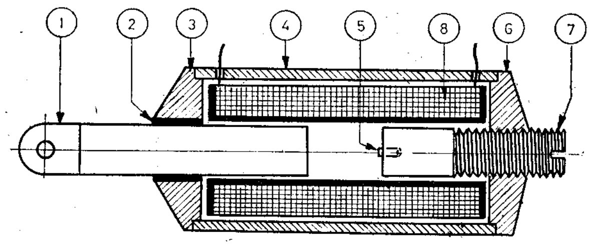
Table 10 gives the number of amp-turns required to establish various flux densities across various lengths of air gap. It is always advisable to be generous; and excess of amp-turns and pull will not be detrimental. Air gaps between the poles and armature must be kept short in proportion to distance between poles otherwise leakage lines will assume an excessive figure.

Where comparatively long pulls are required it is advisable to use solenoids of the type shown in Fig. 17 which will be self-explanatory. Part 5 de-gaussing pin is to ensure that a very slight air-gap always exists, for if the magnetic circuit is continuously iron the magnetic flux, once established, tends to remain after the current is switched off and the armature will tend to stick to the pole pieces.

Fig. 18 illustrates a convenient type of double-acting solenoid.

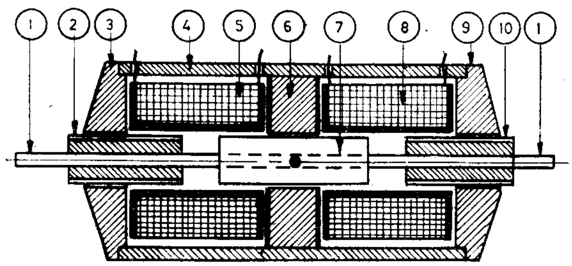
(● *To be continued*)

Below, Fig. 17: Solenoids are more suitable where long pulls are required

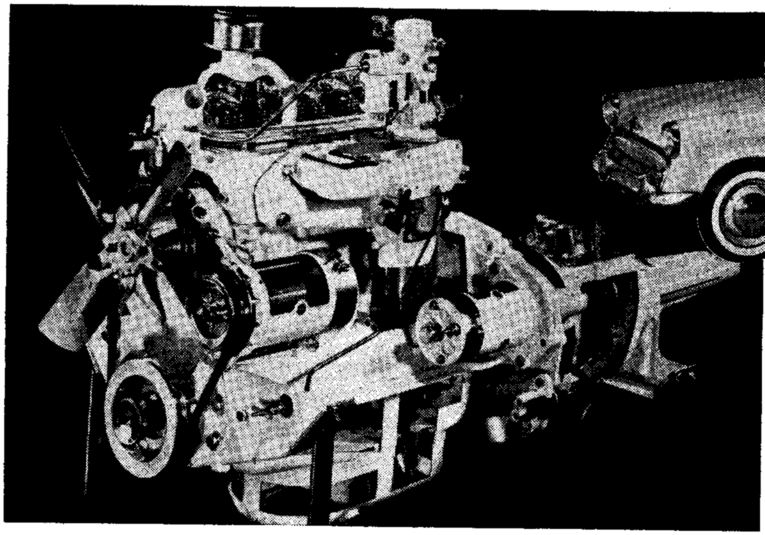


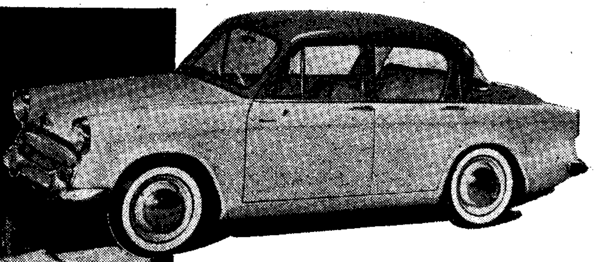
PART NO	NAME	MATERIAL
1	ARMATURE	IRON
2	BUSH	BRASS
3 & 6	END CAPS	IRON
4	SHROUD	IRON
5	DE-GAUSS PIN	BRASS
7	END POLE	IRON
8	COIL	INS. WIRE

Below, Fig. 18: A convenient type of double-acting solenoid



PART NO	NAME	MATERIAL
1	MOTION ROD	BRASS
2 & 10	END POLES	IRON
3 & 9	END CAPS	IRON
4	SHROUD	IRON
5 & 8	COILS	INS. WIRE
6	CENTRE POLE	IRON
7	ARMATURE	IRON





The HEART of the HILLMAN

This cut-away shows the clean lines of the power unit. With a capacity of 1,390 *c.c. this lively o.h.v. engine develops* 51 *b.h.p. at* 4,600 *r.p.m.*

THE LATEST Hillman Minx offers an interesting study to the man interested in the development of motor car engines.

In its original form 24 years ago the Minx was powered by a side-valve engine producing a little over 20 b.h.p. at a speed of about 3,500 r.p.m.

Over the years the engine has been modified and improved until now it develops 51 b.h.p. at 4,600 r.p.m. There is, of course, no single reason for this tremendous increase in performance but among the most important is the adoption of push-rod-operated overhead valves; " squaring " the bore and stroke; increasing the compression ratio to 8 to 1; and enlarging the capacity to 1,390 c.c. (76.2 mm. bore and stroke).

The engine has a three-bearing crankshaft and the short stiff conrods are fitted with generous steel-backed white-metal big-end bearings.

An eccentric lobe type pump gives a constant supply of oil to all the moving parts and to combat the modern bogy of contaminated oil, a full-flow lubricant filter is used.

Although the engine is a high-speed unit with a fairly high compression ratio, it is by no means a " top-end " only performer. The power is developed progressively throughout the range and the flexibility of the unit is unusually good.

A four-speed gearbox (4.778 : 1; 7.126 : 1; 11.807 : 1 and 17.045 : 1 are the forward ratios with 22.726 : 1 for reverse) is fitted as standard, but first gear is regarded largely as an emergency ratio to be used for such extraordinary situations as starting from rest on a steep hill with a heavily-loaded car.

From the purist's point of view, this statement will be greeted with raised eyebrows but for the average driver, the opportunity of being able to miss one sequence of gear changing will doubtless cause a certain amount of relief.

The gears are operated through a steering-column mounted lever and synchromesh is employed for the top, third and second ratios. A stop on the reverse position prevents accidental engagement.

The clutch is a single-plate dry unit of 7¼ in. diameter and is hydraulically operated from a pendant pedal.

A point of minor interest, incidentally, is the scrapping of the starter button. The action of switching on the ignition also starts the engine. ■

Parting-off TOOLS

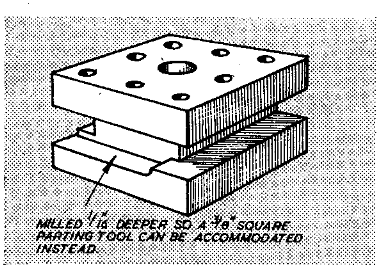


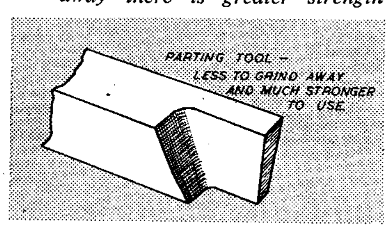
Fig. 2: A $\frac{1}{16}$ *in. ledge milled in the turret allows much larger tools to be accommodated*

THIS IS A suggestion for a modified tool shape and a modification to the four-tool turret, which materially aids the parting-off operation.

In the tool in Fig. 1, which shows less metal ground away at the bottom of the blade, there is much greater strength. Still this tool will part off a piece of metal just as large as a tool ground without the slanting grind. The cutting angles are the same, also the lip if desired.

The turret in Fig. 2, which shows a $\frac{1}{16}$ in. ledge milled off one of the tool surfaces on a four-tool turret, can accommodate larger square tool bits. When this side is used for the parting tool a deeper blade is permitted. The combination of the modified grind on the tool bit, and the use of a bigger square section makes a lot of difference.

Fig. 1: *With less metal ground away there is greater strength*



I have used these ideas for years but I have never seen them in general use. In fact, we are still told to grind a parting tool unnecessarily far back at the bottom of the blade. The fact that it is easier and quicker to grind the parting tool in my way makes it no less attractive.—FRED MASSEY. ■

Selective

AUTO POWER FEED

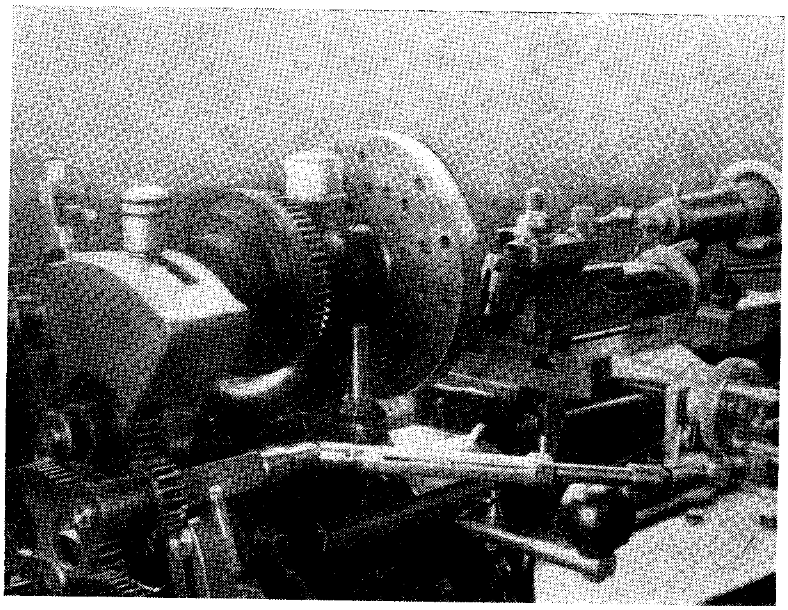
to the

lathe cross-slide

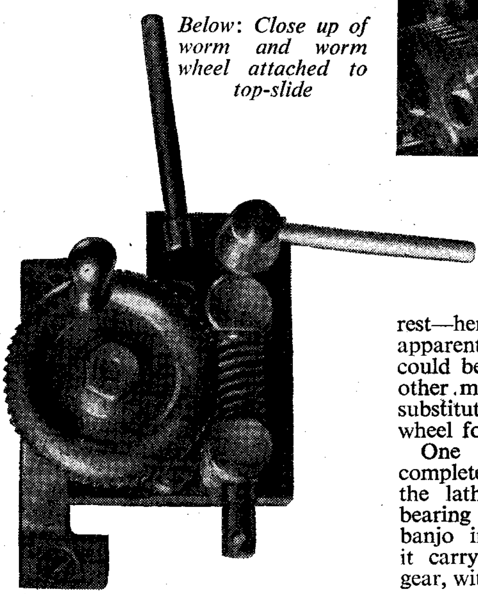
JOHN D. ELAM gives constructional details of a lathe attachment that costs little to make but will prove very useful

FROM TIME TO TIME an article appears in MODEL ENGINEER on this subject but to my way of thinking they have involved far too much construction and some permanent attachments. To anyone who is fond of making his own accessories the facing of a 6 in. dia. surface—taking a roughing and finishing cut only—is a tedious job, so I decided to have a go at designing and constructing one for my lathe.

Up and down this country alone their must be some hundreds of original type 3½ in. Drummond lathes. These were sent out fitted with disc wheels to feedscrews of compound



Above: *Complete attachment in use on the lathe*



Below: *Close up of worm and worm wheel attached to top-slide*

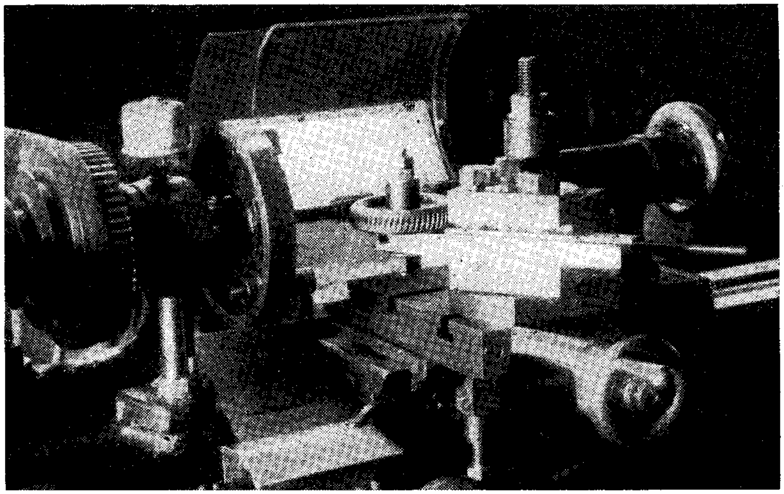
rest—here was my clue. It will be apparent that a similar attachment could be fitted to quite a number of other makes of lathes by the simple substitution of a disc to form worm wheel for their present handles.

One of the pictures shows the complete attachment in action on the lathe. It consists of a plain bearing fixed by a bracket to the banjo in the lathe, the spindle of it carrying on one end the selected gear, with distance and driving collars. At the other end is a ball-type universal joint, one half of which is attached to a telescopic tube, key-wayed to take a keyed internal rod. This latter is also attached to one side of a second universal joint, which in turn is attached to the worm-shaft. Through the worm wheel the shaft gives the feed to the topslide. All joints are secured by screw ended pins.

As circumstances and material in hand may vary in each case I shall apply my remarks to my particular job. I started with the hand wheel. This was approximately 2½ in. dia., and in calculating I found that this was about right for a 60-tooth wheel of ⅛ in. pitch. But with a single-start

Selective AUTO POWER FEED to the lathe cross-slide . . .

worm and a 10 t.p.i. feedscrew to the topslide, driven at mandrel speed, an absurdly fine feed of 1/600 of an inch would result. So a three-start worm was decided on, i.e. $\frac{3}{8}$ in. lead, $\frac{1}{8}$ in. pitch with diameter of $\frac{5}{8}$ in.



The worm wheel being hobbed

Use for a king-pin

The pictures show the worm wheel being gashed and cut by hob. As this process has been described in the MODEL ENGINEER by others far more qualified than I am I shall pass this over by just saying that the hob was turned from an old motor-car king-pin, after it had been softened and later case-hardened. It does not show the least sign of wear and looks capable of cutting many more wheels.

As the picture shows, the worm is mounted on two phosphor-bronze pillars attached to a motion plate, which is free to pivot on a shouldered screw secured to the baseplate attached to extension on the top-slide.

The worm is engaged or disengaged by lifting the motion plate by the lever attached to the top right-hand corner and clamped by levered long nuts.

Range of feeds

In practice if a 20-tooth wheel on the mandrel drives a 20-tooth wheel on the attachment a feed of 1/200 in. per rev. will result, and by varying the wheels 20, 25, 30 and 40 teeth as drivers and driven, feeds of 1/100 to 1/400 can be obtained. For parting off, the continuous feed prevents any digging-in, provided the tool is properly ground and set and the slides are correctly adjusted—when one can proceed with confidence.

One great advantage of this attachment is that it can be attached or unshipped in two or three minutes by removing one nut on the banjo, swivel screw and clamp-nut, or by removing the pin through the worm spindle the shaft drive complete can be alone removed leaving the worm attached to the slide, which causes no inconvenience.

Optional extras

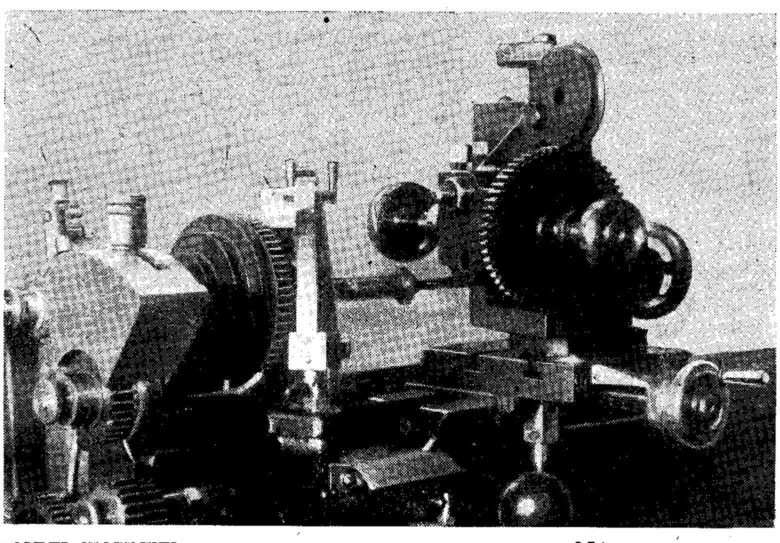
The illustrations also show some of the improvements I have made to this lathe, i.e. reversing gear, pre-set automatic clutch release, electric flash thread pick-up and bull-gear dividing attachment. Fitted to the cross-slide, but not visible in the picture, are adjustable stops for sizing " in or out " diameters.

To my mind a point of bad design in this lathe was the method of clamping the tailstock by tightening on to V-ways, thus causing the saddle adjustment to vary. I overcame this by fitting a lever-operated cam behind the front V-way and a suitably shaped clamp to operate on the flat underback V-way. This insured that the front of the tailstock was in intimate contact with the front way of the bed, while the back clamp locks it most effectively without causing any strain.

Negligible cost

As the cost of the attachment described is almost negligible—the universal joints being Government surplus—it has already paid for the few hours taken in its construction by the pleasure and satisfaction it has given in use. ■

Set-up for dividing and gashing the worm wheel. Note also bull-wheel worm dividing attachment (not in use)



Expert's Workshop

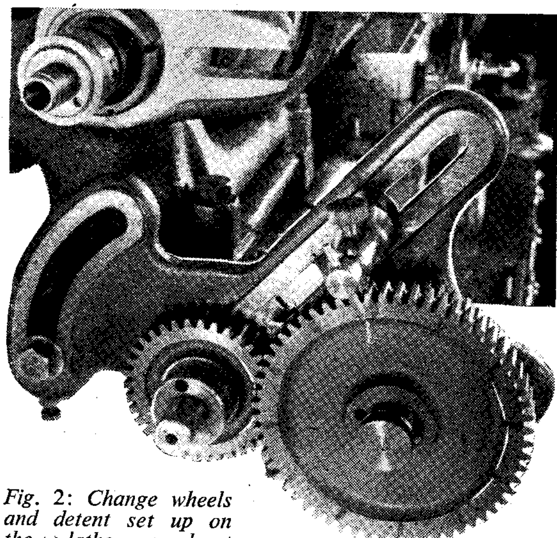


Fig. 2: Change wheels and detent set up on the lathe quadrant

Machining RACKS in the lathe

DUPLEX discusses the problem of cutting the teeth of racks to various diametral pitches

IN COMMERCIAL PRACTICE racks for gearing with toothed pinions are usually cut in a horizontal milling machine, but in the small workshop the lathe is, perhaps, generally used for this purpose and the work, when secured to the saddle, is traversed by means of the leadscrew for machining the rack teeth at the correct pitch distance apart.

Where the teeth of the pinion are cut to a fractional-inch circular pitch there is little difficulty in spacing the rack teeth; for full or fractional turns of an $\frac{1}{8}$ in. pitch leadscrew will then give the required spacing. But the problem is more complicated when working to a diametral pitch; that is to say one where there is a specified number of teeth to each inch of the pinion's diameter and not its circumference as in the case of circular pitch.

As involute gearing of diametral pitch is in general use in the construction of machine tools and other mechanical appliances, racks of corresponding form are those most commonly required.

Ratio of pitches

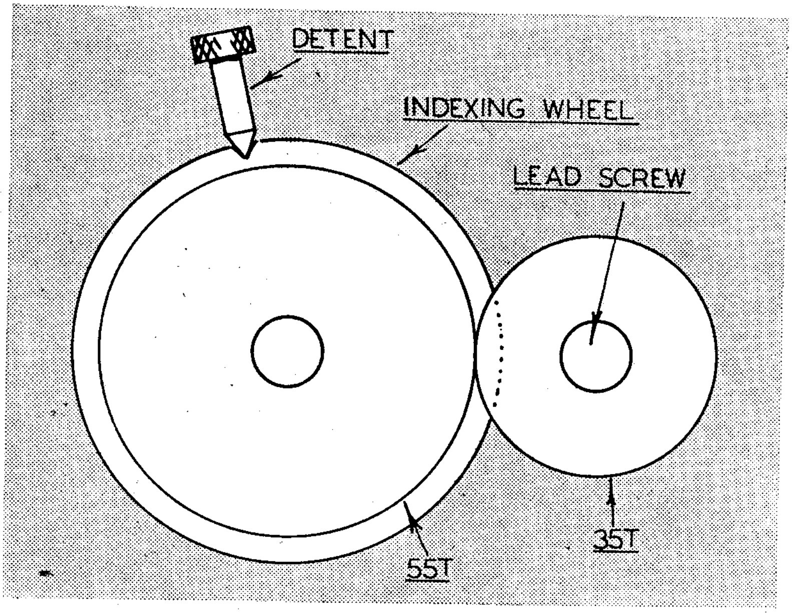
The spacing of rack teeth is expressed in terms of linear pitch, which corresponds to the circular pitch of a toothed wheel of infinitely large diameter where the circumference can be regarded as forming a straight line. Circular pitch is equal to the ratio between the circumference and the diameter of a circle, expressed as π, divided by the diametral pitch, that is to say $\frac{\pi}{\text{d.p.}}$

If the figure $\frac{22}{7}$ is adopted to represent the π ratio, the error amounts to only some 0.04 per cent. of the true value of π when calculated to four places of decimals, and the corresponding pitch error in a 20 d.p. rack is then equal to 0.00006 in.

Although a pinion meshing with a slightly out-of-pitch rack will automatically adjust its working pitch to conform with that of the rack, smoother working will be obtained if the rack is of the correct pitch; and the latter is essential where the rack and pinion form part of an accurate measuring instrument.

Where, for example, a rack has to be cut to gear with a pinion of 16 d.p., the tooth pitch of the rack is 0.196 in. But, except where the leadscrew of the lathe is 1/10 in. pitch and its index collar can be set to zero, it is not always an easy matter to turn the leadscrew many times in succession in order to traverse the saddle an

Fig. 1: Diagram showing the change wheel arrangement for accurately indexing the rack teeth



Machining RACKS in the lathe . . .

exact number of thou. inches.

This difficulty can be overcome by fitting the lathe quadrant with a gear train that will enable an indexing wheel to be turned so as to traverse the saddle for a distance equal to the pitch of the rack teeth. Suitable change wheels for this purpose are found in the following way:

$$\frac{22}{7} = \frac{11 \times 2 \times 5}{7 \times 5} = \frac{55 \times 2}{35}$$

If, therefore, a 55 t. change wheel is used for indexing by means of a detent and, meshing with it, a 35 t. wheel is secured to the leadscrew, one complete turn of the indexing wheel will traverse the saddle for a distance equal to the tooth pitch of 0.196 in. of a 16 d.p. rack.

Although the 55 t. wheel can be used for indexing full revolutions, wheels of other sizes are needed to enable fractional parts of a turn to be indexed in accordance with the requirements of the system. If necessary, an idler wheel can be interposed between the two driving gears without upsetting the overall ratio.

Avoiding errors

In Table 1 the indexing arrangements are given for cutting the teeth of racks of various diametral pitches, in conjunction with the 55 t. and 35 t. driving wheels.

In order to avoid errors when advancing the indexing wheel it is advisable to set the dividers to embrace the number of tooth spaces required and use as a setting gauge.

In this way, when advancing a 35 t. wheel for a 40, the dividers are set to span five tooth spaces and the indexing wheel is turned through one revolution, plus this amount. Again, to advance a 60 t. wheel for a 48, the dividers are set to span twelve tooth spaces and the wheel is turned for one revolution, less this distance.

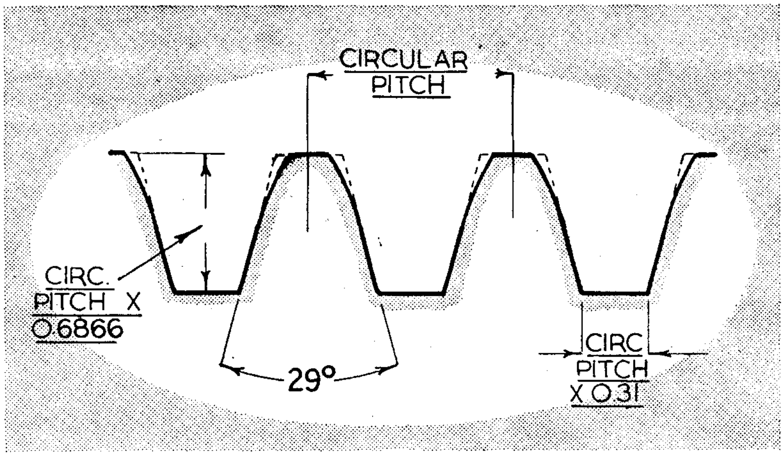


Fig. 3: The main characteristics of normal rack teeth

Chalk marks that can be easily rubbed out and replaced on the rim of the change wheel are a great help.

Racks cut by adopting this arrangement of change wheels have tooth pitches nominally correct to four places of decimals; this should be sufficiently accurate for use in the mechanism of, say, a dial test indicator.

As shown in Fig. 2 the wheel train set up on the lathe quadrant is used to actuate the leadscrew only and has no connection with the lathe mandrel. For cutting racks of simple fractional-inch pitch to gear with wheels cut to circular pitch a single 60 t. wheel is secured to the leadscrew so that it can be indexed, by means of a detent, into whole-, half- or quarter-turns, corresponding to $\frac{1}{8}$ in., $\frac{1}{16}$ in. and 1/32 in. traverse of the saddle, respectively, with an $\frac{1}{8}$ in. pitch leadscrew.

As represented in the second table, spacing the rack teeth can be carried out by indexing directly from the driving wheel and dispensing with a special indexing wheel. As before, the driven wheel is secured to the leadscrew. Although with this arrangement the driving wheel is turned for a complete revolution or a multiple of this amount, and the indexing is therefore simplified, a considerable error is in some instances introduced.

This pitch error may not be sufficient to prevent the pinion engaging with the rack, but there may be some interference between the teeth which would militate against smooth and accurate working.

So far only the methods of pitching the rack teeth have been described, leaving the other factors affecting the form of the teeth to be dealt with. The whole depth of tooth is the term used to indicate the depth to which the teeth are cut in order to provide adequate working clearance.

As represented in Fig. 3, this amounts to the value of the circular pitch, expressed in inches, multiplied by the constant 0.6866; but where the diametral pitch is given, this is divided into 2.157 to obtain the tooth depth.

The rack teeth are formed with an included angle of 29 deg., and the crests of the teeth may be rounded off to prevent interference. The width of the space lying between the roots of adjacent teeth is equal to the circular pitch multiplied by 0.31.

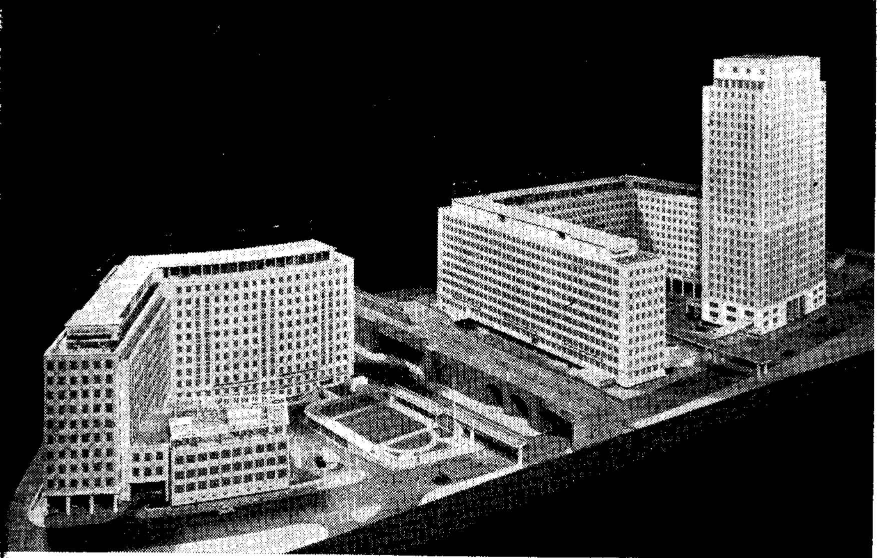
(● *To be concluded*)

TABLE I

Diametral pitch	Linear pitch	Indexing wheel	No. of teeth indexed
12	0.262	60	80
14	0.224	35	40
16	0.196	60	60
18	0.175	45	40
20	0.157	60	48
22	0.143	55	40
24	0.131	60	40
26	0.121	65	40
28	0.112	35	20
30	0.105	60	32
32	0.098	60	30
36	0.087	45	20
40	0.079	60	24

TABLE II

Diametral pitch	Driving wheel	Leadscrew wheel	Turns of driver	Pitch error thou. in.
12	40T	38T	2	1
14	45T	50T	2	1
16	40T	50T	2	4
18	35T	25T	1	—
20	50T	40T	1	1
22	40T	35T	1	—
24	40T	38T	1	—
26	75T	80T	1	4
28	45T	50T	1	—
30	80T	95T	1	—
32	40T	50T	1	2
36	35T	50T	1	—
40	25T	40T	1	1



How the proposed Shell offices would look to passengers in a plane approaching from Belvedere Road. The 330 *ft.-high tower block is on the right*

be a specially-designed form of night-illumination. The two flanks of the U-shaped lower office blocks will be placed on columns to allow free passage across the courtyard from York Road to Belvedere Road. Visitors to and users of the site will be treated to a breadth of vistas unexampled in any permanent group of London buildings.

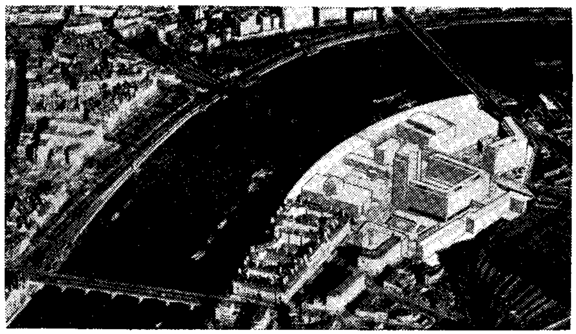
High-level catwalks will give pedestrians freedom of movement between Waterloo Station, the future hotel upstream, Belvedere Road and the Festival Hall.

One of the major departures from the original L.C.C. scheme is the abandonment of the air terminal which is to be moved to the Cromwell Curve, Kensington site. While this is a loss of an interesting activity, it may be conceded that the proposal for a terminal building directly opposite to the National Film Theatre might well have created certain problems of traffic embarrassing to the users of these buildings.

The other main change is that the plan for the conference centre and exhibition gallery has been abandoned and the site between the Royal Festival Hall and Waterloo Bridge is now intended for a small concert hall.

The Shell offices will be characteristics in their expression of a British contemporary architecture. ■

LONDON'S *NEXT* *LANDMARK*



ON VIEW at the Summer Exhibition of the Royal Academy which opened to the general public on Saturday May 5, is a $\frac{1}{16}$ in. model of the new main offices in London of the Royal Dutch/Shell Group of oil companies.

The basic idea is a development benefiting Londoners and visitors to London. The presence of the National Film Theatre, the Festival Hall, a smaller concert hall and a riverside hotel, guarantees that the area will not run the risk of commercial development.

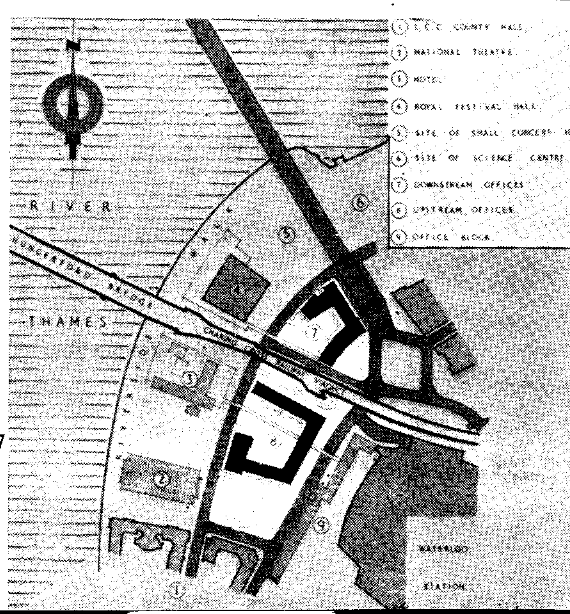
The Shell offices have been designed by Sir Howard Robertson, A.R.A., a past-president of the Royal Institute of British Architects. They will comprise two blocks on either side of Charing Cross railway viaduct, one upstream and the other downstream.

The upstream block is to be built on three sides of a square with the open side facing the Thames. Consisting of 11 storeys and rising to a height of over 150 ft. it will be dominated by a 26 storey tower, over 330 ft. high.

The downstream block will comprise an L-shaped, 11-storey building abutting another of only three storeys, fronting on to Belvedere Road. The design of the office development has been worked out on the basis of the L.C.C.'s 1953 plan, but in meeting the functional requirements there have naturally been some departures from the bulk and massing of the blocks.

There will be a spacious, well-laid-out square facing the National Theatre and incorporated in the scheme will

Above, right : An aerial vantage of the development scheme for the South Bank



Right: The plan of the site

POSTBAG

The Editor welcomes letters for these columns, but they must be brief. Photographs are invited which illustrate points of interest raised by the writer

THE DIESEL

SIR,—I have to thank Mr. Woodcock for the interesting information he gives in reply to my query about blow-backs in locomotives and on the fitting of blowers.

I was familiar with Chas. Markham's successful solving of the problem of burning coal in a locomotive firebox. As with many successful inventions of fundamental importance, Markham's solution was chiefly remarkable for its simplicity. A study of some of the weird and wonderful fireboxes designed to burn coal and detailed pretty fully by Ahrons in his *British Steam Locomotives* 1825-1925 will immediately show the value of Markham's contribution.

Some of the boilers used previously must have been fantastically expensive both in first cost and in upkeep; they can only be described as boiler-maker's, firemen's and maintenance men's nightmares.

Mr. Woodcock is entitled to think what he likes about diesel engines, but his examples fail to convince me of the justice of his use of the term "shoddy" to describe them.

He is arguing from the particular to the general, in itself a thoroughly unsound practice. To argue from four isolated instances, at least one of which has nothing to do with diesel engines, smacks of prejudice.

There are many thousands of diesels ranging in power from three or four h.p. up to thousands of h.p. made in this country every year. If there was any general truth in Mr. Woodcock's accusation of shoddiness their makers, instead of continually expanding their home and export business, would quickly find themselves in bankruptcy.

In my younger days I had a lot of experience with the maintenance and repair of locomotives for contractors work, quarries, mines, etc., and I came across instances of faulty workmanship and material quite as bad as those instanced against the diesel by Mr. Woodcock, but I do not condemn the whole breed as shoddy because of that.

The diesel engine is ousting the steam locomotive because those in the best position to know believe it to be the better proposition. As the world is constituted today, a machine is assessed on its economic value and a shoddy product will not get far. I think the diesel will!

Rustington, W. Sussex. K. N. HARRIS.

SPAM CANS

SIR,—It is amazing—or "amusing" would be a better word—to note the trivialities which are put forward in a frantic endeavour to catch me napping.

If Mr. Currey (Postbag, May 10) had read my article carefully, he would have seen that I described the *original* Strowger-Hudd gear, and not the modification applied to the Fenchurch St.-Southend line. I was not responsible for the caption printed beside the diagram. Incidentally, the G.W.R. system is more than 30 years old, but still functions satisfactorily without alteration.

If the G.W.R. bell only rang for a fraction of a second, what would be the object in fitting the delayed action relay? If Mr. Currey has ever travelled on the footplate of a locomotive at high speed, he should know how much roar and clatter there is. The bell has to ring long enough and loud enough to give plenty of warning above the noise—one tinkle would be useless.

In answer to Mr. Coffin (same issue) the old Brighton drivers did not consider the thumping of big ends as "music"—they promptly put "Big-end-brasses need taking up" in the report book! The "spams" occasionally pass here on excursions and parcels trains, and I can tell them a mile off by the heavy running—the exhaust beats are often three loud and three soft, with an occasional disappearance of some altogether.

I did not christen the engines "spam cans," the nickname was bestowed on them by Southern enginemen. I have also heard them called "coffins" and I wonder what Mr. Coffin thinks of that!

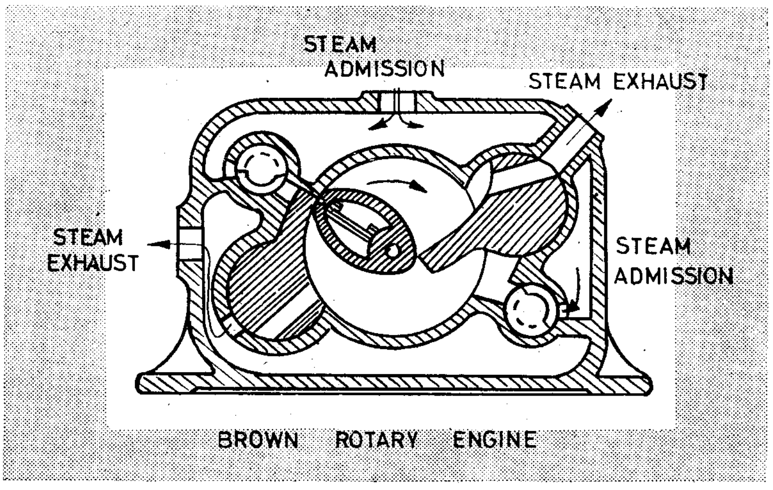
L.B.S.C.

● *It must be pointed out that Mr. Coffin did not refer to the thumping of the big ends as "music." It was the exhaust note of* 35021 *that provided the music.*—EDITOR.

ROTARY ENGINES

SIR,—On reading "Rotary Retrospect" in the April 19 issue I was reminded of an illustration of a rotary

Rotary engines are not new. This one was designed at the turn of the century See "Rotary Engines"



steam engine which appears in Vol. 1 *Modern Power Generators.* The word "modern" has by now lost its significance as the books were published in 1908.

I am enclosing a pencil sketch of a sectioned engine and hope it may prove of interest. The test describing it is as follows:

"The small radial piston sweeps round the cylinder about a longitudinal axis, under the action of the steam upon the one side. Hinged pallets, which also act as steam-distributing valves, bear upon the piston and prevent the steam from escaping directly to the exhaust. . . .

"It is largely the difficulty of making the contacts of such pallets with the piston sufficiently steam-tight that has involved the failure of so many attempts. George Stephenson declared that the difficulty of making a line contact permanently steam-tight made the problem of the rotary engine insurmountable. So far the statement remains true." That was in 1908.

Cheshire. W. SIMONS.

NO COPYING

SIR,—In his note on locomotive likenesses, Vulcan (Smoke Rings, May 10) calls attention to a remarkable case of apparent copying in his reference to the similarities between Mr. Robinson's G.C.R. Atlantics and Mr. Reid's N.B.R. Atlantics.

I suggest that the similarity is more apparent than real—in fact not so very apparent.

Both engines had identical wheelbases while their wheel discs, too, were identical, and there the similarity ends.

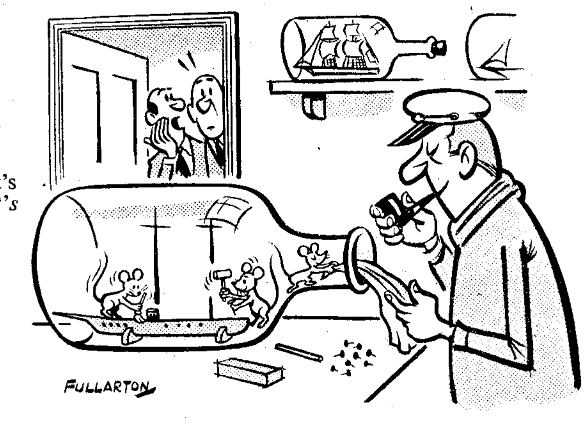
The following dimensions are all of major importance, and the superiority of the N.B.R. engine from a power point of view is outstandingly obvious:

	N.B.R.	G.C.R.
Boiler: heating surface, tubes	sq. ft. 2071	sq. ft. 1778
Heating surface, firebox ..	184	133
Total ..	2255	1911
Grate area ..	28.5	26.0
Boiler C/L above rail	ft. in. 8 11	ft. in. 8 6
Working pressure	p.s.i. 200	p.s.i. 180
Cylinders:	20 in. × 28 in.,	19½ in. × 26 in.
Tractive effort at 85 per cent. boiler pressure	23,500 lb.,	19,600 lb.

The N.B.R. engine has 18 per cent. more heating surface (38 per cent. greater firebox H.S., a most important feature), 9½ per cent. more grate area and 20 per cent. more tractive capacity.

Incidentally, the tender, too, of the N.B.R. engine was considerably larger than was that of the G.C.R.

Aha, so that's *the way it's done* !



A study of these facts will, I think, convince anybody that there is precious little evidence of any "copying" on the part of Mr. Reid.

There was a remarkable similarity in engine wheelbase diversions among the British Atlantics or, at least, most of them.

N.B.R., 27 ft. 9½ in.; G.C.R., 27 ft. 9½ in.; G.W.R., 27 ft. 9 in.; G.W.R., 28 ft. 6½ in. (French compound); N.E.R., 28 ft. 0 in.; G.N.R., 28 ft. 3 in. ("Vulcan" compound); L.Y.R., 27 ft. 9 in.

Ivatts G.N. and Marsh's L.B.S.C.R. were, of course, as Vulcan says identical and shorter than most at 26 ft. 4 in.

Rustington, West Sussex. K. N. HARRIS.

THREE FACTORS

SIR,—The letter of Henry O. Ellis of Plymouth (Postbag, May 3) headed "Slave and Master" sounded to me a little dogmatic. The late Mr. Hope-Jones was, of course, the greatest living authority on the Synchronome, which is one of three commercial adaptations of the electrically-restored gravity-arm impulsed pendulum invented by Shepherd in 1849. There are two others in general use, and amazingly fine limits of timekeeping are claimed, and not disputed, by all three.

It is fortunate that Mr. Ellis says, "It is the only system I *know* (my italics) which has been designed rigidly in accordance with the laws of electricity and horology" and we can only assume that he does not know of the Parsons and Ball, or the Garrett and Johnson systems, the other two mentioned.

Mr. Ellis seems to assume that electricity and horology are the only laws which have to be observed forgetting the third and equally important mechanical factor.

The famous Hipp pendulum, many examples of which have outlived the firms which made them, was perfect electrically and horologically but unless precision made was liable to mechanical faults.

The Bain and its imitators, one of which was the once well-known Bulle, was perfect mechanically and electrically but faulty horologically. The Fery and the Campiche were perfect mechanically and horologically but faulty electrically, and though my purpose here is not to split hairs it is incorrect to set up only two standards where at least three are involved, the failure of any one of which can bring many systems (apart from those mentioned) into disrepute commercially and scientifically.

In most textbooks earlier than the one mentioned, which is fairly recent as such textbooks go, the term "slaves" is freely used in connection with the secondary movements of master transmitters and Mr. Ellis is less correct in referring to the coil of a dial than others who refer to these movements as "slaves" which, of course, operating on an impulse from a master, they are.

The driving impulse to the free pendulum coming from a standard Synchronome clock, it is a matter of opinion which is the master and which the slave—a term in common use long before the Synchronome was designed. On to what size former does Mr. Ellis wind his 4 oz. of No. 24 enamelled wire to get the requisite number of ampere turns? Is not this worth mentioning? The resistance of the slave coils depends upon the power (watts) available in the master and the henries required to operate the mechanism of the slaves. Most of my systems work on a resistance of 300 ohms per slave coil.

By remarking that *if* one had a watchmaker's lathe one could construct one of these dials (he means of course movements) he seems to imply that one of these precision lathes is necessary and this might deter readers from joining in the fun of home clock-making. I have built a number of masters and slaves on an Adept Super.

I am stronger on pendulum and escapement design than on electrical subjects and make no comment on his closing advice re sparking, but I have found from experience that under certain circumstances where sparking occurs the simple expedient of connecting a condenser across the coils, though generally advised and probably scientifically correct, does not always prove effective. What I try to aim for is to have the mechanism as sensitive as possible so that it will work efficiently with the lowest magnetic pull possible from a coil of as high a resistance as possible.

Paddington, London, W.C. J. A. ROBERTS.

DOUBLE MEANING

SIR,—In reply to your correspondent E. J. Lees (Postbag, May 10) the term "flexibility" has a double meaning. First, covering the ability of a steam locomotive to operate from ultra-low power to extremely high overload, as all drivers can confirm, a diesel or straight-electric machine has a maximum rating beyond which it is not safe to operate. In bygone days drivers who were conscious of this reserve power often screwed down the spring balance (the safety valve of those days) to increase this flexibility still further! Secondly, but very important in these days when electrification of the main lines is contemplated, the steamer, with the diesel machine, possesses great flexibility in that, subject to acceptable overall dimensions and axle loadings, it can operate over any part of the entire system. The straight electric is a "tied" machine—tied to the third rail or overhead cable.

Regarding Mr. Lees' remarks on the subject of maintenance I do not feel that these call for any other comment than that, if the powers-that-be discard steam for diesel or straight-electric, naturally the men skilled in the construction and maintenance of steam locomotives will die out—as skilled blacksmiths are disappearing.

No, sir, my article was not stale as Mr. Lees suggests in his fourth paragraph, but perfectly up to date. There would appear to be two schools of thought even on British Railways. One still holds to their faith in steam and, having permission to develop their standard of designs, presumably to carry on with until the electrification scheme is in being; the other school believes in electrifying everything on wheels—reminding me of one firm who had such faith in the diesel-electric as to apply that system even to a 5 ton quarry locomotive!

As regards the Santa Fe Rd., I gave the information as I received it and have still no reason to doubt it, as I have found from personal experience that my informant, the editor of *Light Steam Power*, is invariably up to date.

Mr. Lees' remarks about the Algerian Garratt locomotives having been withdrawn from service owing to a change of policy do not alter the point I sought to make in my article, namely, that one Garratt engine, when compared with two British Railways d.c. 10,000 class locomotives, is superior on three out of the four vital characteristics quoted.

Keswick, Cumberland. GEORGE W. MCARD.

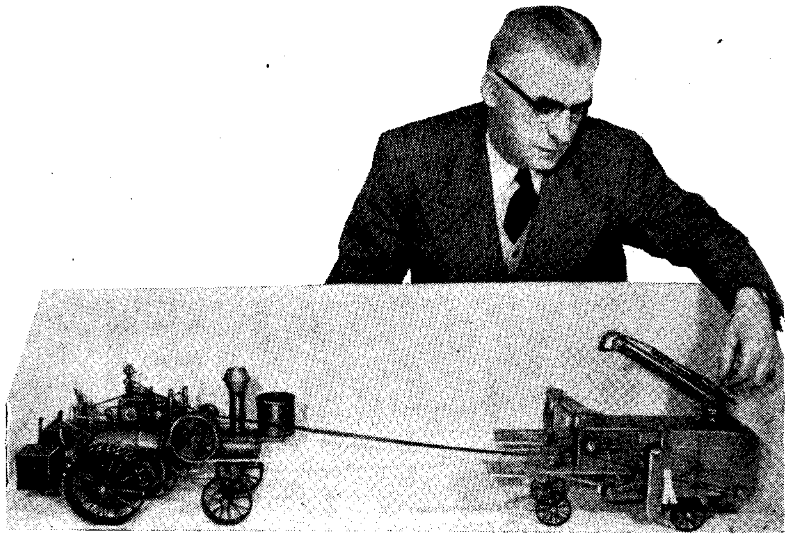
THE MAJESTIC

SIR,—In reply to Mr. Ballemy's letter (Postbag, May 10), I do not possess a copy of the cross-section drawing he mentions, but in view of his remarks it seems that the drawings cover *both* arrangements of safety-valve.

All the 4-2-2 engines from No. 3031 were built with steam sanding gear. Nos. 3001-3030, when built as 2-2-2 engines had gravity sanding, but were altered to steam sanding when converted to 4-2-2.

Regarding the pressure gauge, the type with bottom-pivoted needle is correct.

Midgham, Berks. J. N. MASKELYNE.



This ¾ in. scale traction engine is fired by a 600 watt heater. The thresher is complete with fans, beaters and stacker pipe. (Picture by W. H. Ellwood)

EXPANDING TO NOTHING

SIR,—I have just read Mr. W. Johnson's (Postbag, April 5) and feel it is an apt occasion to quote: "people who live in expanding universes should not throw stones." If they do they will find that the stone expands along with the rest of the universe and any given mass subject to such expansion has a density which can decrease to zero.

In other words, the line drops through the bottom of the graph and the stone vanishes. Likewise light, and other wave forms of energy; they can all be spirited out of existence by the touch of the mathematical wand. Expand time as well as space, and you get complete nothingness.

Coming back to earth (literally), expanding dimensions really only bother astronomers and fashion-conscious females, while prosaic Newtonian physics will haunt the ghosts of the perpetual motion fans, perpetually.

Mukonje, British Cameroons. CONSTANT PLANK.

★ ★ ★ READERS' QUERIES

This free advice service is open to all readers. Queries must be of a practical nature on subjects within the scope of this journal. The replies published are extracts from fuller replies sent through the post: queries must not be sent with any other communications: valuations of models, or advice on selling, cannot be given: stamped addressed envelope with each query. Mark envelope clearly " Query," Model Engineer, 19-20, Noel Street, London, W.1.

Model tug

Q I am constructing a small model tug 16 in. in length to be driven by a small but powerful oscillating steam plant which I have ready made. I wish to use a solid-fuel boiler on the lines of the one described in " More Utility Steam Engines " in MODEL ENGINEER No. 2776, Vol. 3, August, 1954, and termed the " annular " type, as fitted in the launch *Blitza.*

It must be suitable for a space 4 in. high by 2½ in. across, but with plenty of room fore and aft. Perhaps it might be oval? I thought of using charcoal as a fuel. Could you, therefore, let me have a little more information on the constructional side in regard to this boiler? Would charcoal be a suitable fuel with a partly soft-soldered construction?—R.K., Welwyn Garden City, Herts.

A *The success of such a boiler in a craft no more than 16 in. in length would appear very dubious. As suggested, the boiler could be made oval in plan view, but generally speaking it is extremely difficult to use solid fuel successfully in a very restricted size of furnace. It cannot be recommended, in the absence of practical experience with so small a boiler. There is a possibility that the experiment might work provided that it were possible to get a fairly adequate air supply through the grate and also keep up a fairly powerful induced draught by means of a blast-pipe in the chimney.*

Generator problem

Q Having built a d.c. generator which won a silver medal at the Rand Show, I want to begin on the M.E. Kittiwake so as to have a small power plant. I would be glad of your advice on a few points. The generator has a 2 in. dia. pulley driven by a ⅜ in. V-belt (" A " belt actually) and I need 2,800 r.p.m. The maximum output is 180 watts (12 v. × 15 amp.). The field-magnets require ±30 watts and so, allowing for some further losses, I would probably come to 230 watts. What is the maximum output of the Kittiwake? Theoretically I want ± 1/3 h.p. by the 2,800 revs. Is there, generally speaking, a direct link between the c.c. of a petrol engine and the output in h.p. with a moderate c.r. ratio of five or six?—A.H., Johannesburg.

A *It is difficult to say what the sustained output of the Kittiwake engine would be, for though this engine is capable of producing approximately 1 h.p. for sprint work at its maximum power peak, which is in the the region of 10,000 r.p.m., it would not be fair to expect it to run continuously at much more than one-third of this speed, with a corresponding reduction in horse power.*

The suggestion that 1/3 h.p. would be sufficient to drive the generator at full output seems much too optimistic as experience shows that losses are very high on these small machines. If the generator is to be driven by belt, the engine pulley should be about half the size of that on the generator. It would also be advisable with a belt drive to modify the main bearing on the drive side, which should be the same side as the flywheel, so as to incorporate a larger bearing than the one originally specified, or better still two ball bearings spaced about 1 in. apart, so that the shaft will resist side thrust effectively.

There is no direct link between the cubic capacity of a petrol engine and the output in horse-power, for several variable factors are involved and different engines vary considerably in their output per c.c. Generally speaking, it is not advisable for stationary work to design an engine to produce high volumetric output, owing to the heavy wear and tear involved by the extra stresses on all working parts.

Intake on air compressor

Q I have purchased a twin-cylinder compressor advertised in MODEL ENGINEER and I wonder if you will help me in fixing it up. The compressor is described as twin cylinder 1½ in. bore, 1½ in. stroke, 2½ cu. ft., 180 p.s.i. At what speed ought it to be driven and what horse power is required? I can see no air intakes; where are they likely to be? If the cylinders are connected to a T-joint and then to the tank will this be satisfactory? I need the compressor to truck up the car, spray springs with oil, blow tyres up and, if possible, work a ½ in. gas blowpipe.—W.H.P., Stoke-on-Trent.

A *The compressor will presumably have been obtained from refrigerating plant and would be capable of being driven by a ¼ h.p. motor and of working at a speed of about 700 r.p.m. —that is to say, about half the speed of the standard form of fractional horse power motor generally used for driving such compressors. Most of them take their air in through the crankcase. There will probably be an inlet connection on the crank case and probably inlet valves or transfer ports in the pistons. The delivery valves on both the cylinders will discharge into the cylinder head and there will be only one delivery port.*

No drawings

Q I have had a 2½ in. gauge locomotive engine sent me with the frame and the cylinders almost finished, but there are no drawings which, of course, I must have to complete.

The particulars: 2½ in. 4-4-2, Walschaerts valve gear.—D.B., Selby, Yorks.

A *The 2½ in. gauge locomotive which has come into your possession is, of course, an Atlantic type. Mr. H. Clarkson, 11, Monkgate, York, may possibly be able to help you as he is a professional model locomotive builder.*

Paint spraying

Q I would appreciate your opinion as to the suitability of an air compressor (of the type fitted to lorries for tyre inflation) for paint spraying purposes. I have an air receiver of about 1½ cu. ft. capacity and reducing valve with which the compressor could be used.

Would you also advise me at what speed the compressor should be driven and approximate h.p. of motor required.—G.C., Walsall.

A *Several types of compressors can be adapted to paint spraying, though generally speaking, the output would not be of sufficient volume to enable continuous work to be done with the standard types of spray guns. They could, however, be used for intermittent work in conjunction with an air receiver of the size specified. A suitable speed for these compressors would be from 700 to 800 r.p.m., and for working at full output about 1/3 h.p. would be desirable.*