INFRA-RED PHOTOGRAPHY

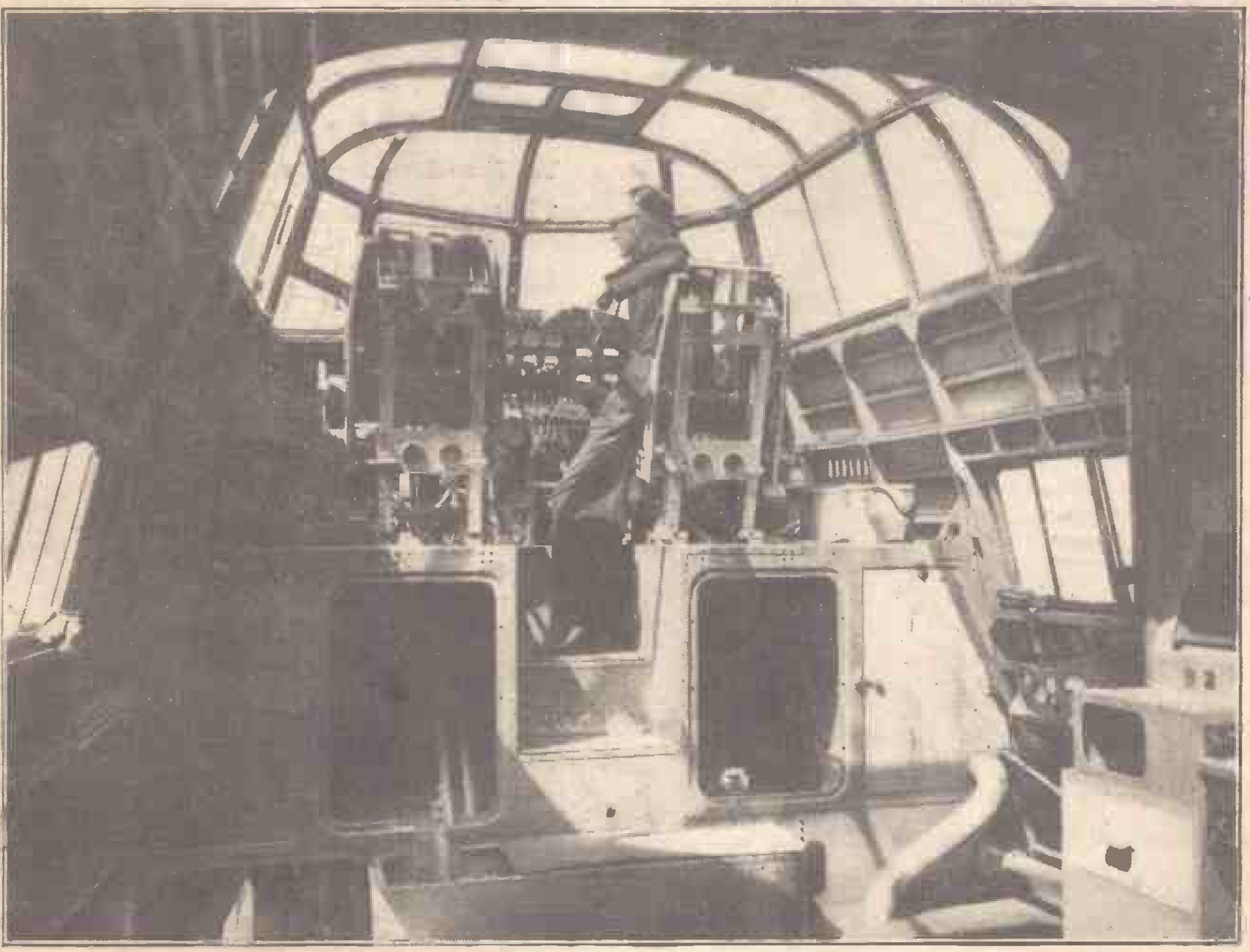
NEWNES

PRACTICAL MECHANICS

9D.

EDITOR : F. J. CAMM

SEPTEMBER 1947



THE SPACIOUS COCKPIT OF THE NEW SHETLAND FLYING BOAT (See page 373)

PRINCIPAL CONTENTS

Rocket Propulsion

Improved Aircraft Rocket Engines

By K. W. GATLAND

(*Continued from page 351, August issue*)

A short runway is no obstacle to this " Seafire " equipped with R.A.T.O.G. Its four rockets, containing 26lb. of cordite apiece, deliver a total thrust of approximately 4,400lb. for four seconds.

THERE are two further applications of rocket power that merit attention before leaving the subject of aircraft propulsion. One is the *rocket booster* for increasing the climbing rate of fighters and supplying them with excess speed during combat; the other, R.A.T.O.G. (*rocket-assisted-take-off*).

The Rocket-boosted Me.262

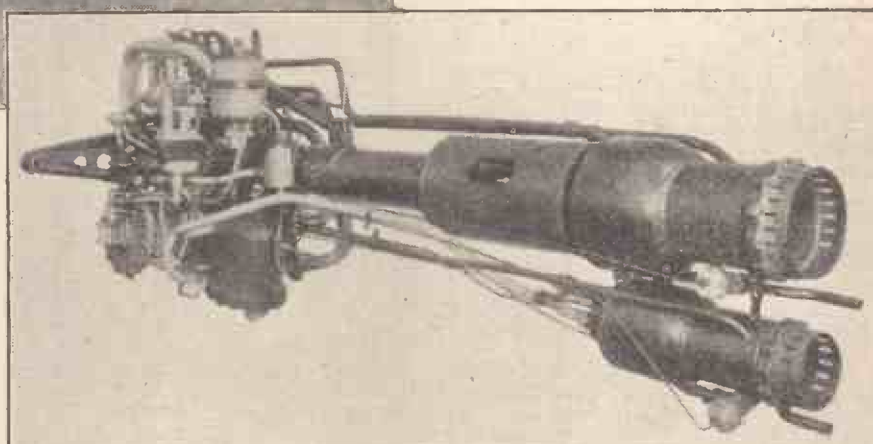
It will be recalled that one of the main reasons for the Ba349 " Natter " not going into service was the outstanding performance put up by the Messerschmitt 262 when rocket units supplemented its normal jet power. Germany's home defence squadrons demanded something more dependable than the pure rocket types, an interceptor, in fact, with the climb of a rocket and the endurance of a turbo-jet.

This conclusion came a trifle too late! Much valuable time and material had been gambled on developing the Me.163 series, the Ju.263, and the Ba.349, and the obvious solution to adapt existing jet fighters with powerful rocket-boosters did not materialise until the war was virtually over and the Rhineland's production centres almost too severely shattered to warrant defending.

High hopes were held of the Messerschmitt fighter thus adapted. Its auxiliary rocket unit was said to impart a rate-of-climb far surpassing that of anything the Allies could put into the air, and the two Jumo 004 turbo-jets, which operated as the main source of power, gave the machine a more practical thrust duration than could ever be expected from the use of rocket drive alone. The prospects were certainly encouraging.

Jumo Engines Under Par

The use of rocket assisted engines in Me.262s seems at first to have been more the nature of a panic measure than a clear-cut scheme to improve the combat efficiency of fighters generally. The fact is that early deliveries of Jumo engines did not give expected thrusts. The rate-of-climb was consequently poor, and so it was decided to incorporate two bi-fuel rocket units to bring the overall thrust up to par.



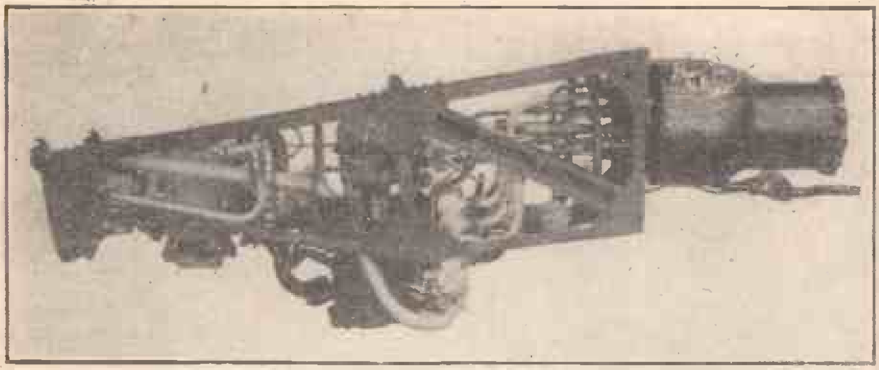
The Walter 109/509C developed for the Ju.263. Its main chamber produced a thrust ranging from 220 to 4,400lb., and an additional 880lb. constant was forthcoming from the smaller " cruising " chamber. (*See* PRACTICAL MECHANICS, *Sept.*, 1946, *p.* 420.)

Produced by the Bayerische Motor Werke under the type number B.M.W.718, the two chambers of the initial scheme were rated to deliver a thrust of 2,760lb. apiece and ran on a self-combusting mixture of Salbei (98 per cent. to 100 per cent. nitric acid) and a brown coal fuel known as J-2. One was placed in each engine nacelle over the jet orifice; they fed from a common pump assembly, the control system fitting to a framework inside the fuselage.

There appears to have been a second version of this installation, one that, though it produced a lower aggregate thrust, improved the power duration. It was somewhat similar in conception to the R.11.203 unit used in the Messerschmitt 163A, but with one combustion chamber in each jet nacelle and the ancillaries separate owing to restrictions in space. The propellant was T-stoff (80 per cent. solution of hydrogen peroxide) with Z-stoff (calcium or sodium permanganate) and thrusts of from 220 to 1,550lb. per unit were available at sea-level, although the maximum thrust had to be reduced progressively to 790lb. after climbing 33,000 feet: this was because cavitation occurred at the pump inlets. An endurance of 110 seconds on full thrust was obtained for a total propellant weight of 3,750lb.

Flight tests of this installation were due in the summer of 1942, but the scheme (like

The Messerschmitt 262 might have been highly effective for " home defence " had rocket boosters arrived in time. This one was captured intact and is seen here with British markings.
(By courtesy of " The Aeroplane.")



One of the neatest rocket engines produced by Walter was this 109/509S2 booster for the Messerschmitt 262. It was mounted externally below the centre-section.

so many others before and after it) was cancelled before any proper trials could take place. Improved *jet* engines had arrived!

The Lull Between

Thus, an idea which might have turned up trumps had more time been given to its development was laid aside. Meanwhile, work continued with primary aircraft rocket engines with the results that we have already seen; but had Germany's technicians been allowed to proceed with controllable rocket boosters, and all efforts concentrated on producing the Messerschmitt 262, the story might have been quite different.

However, it was more than a year later that the German Air Ministry saw fit to revive the contract with Walter, and a second experimental programme was launched in the summer of 1944 under the title "Heimatschutzer."

There were several versions of boost rockets produced under this heading, both by Walter and B.M.W. The first was simply a modified Walter 109/509A2 (as used in the Messerschmitt 163B) fitted in the extended tail of a special Messerschmitt 262. The adapted engine, which had involved some rearrangement of its components in order to bring forward as much of the weight as possible, was known as the 109/509S1; the performance figures quoted for the two units were near enough identical.

The best figures for climb put up by this machine—with the rocket unit supplementing the thrust of twin Jumo 004 turbo-jets at "maximum safe" boost—was 170 seconds to reach 23,000ft. The test took place at Lechfeld in February, 1945, but although the performance was encouraging, the installation was so bad from the maintenance point of view that it could not be used in service. Therefore, work on a second Walter engine, the Heimatschutzer IV (the intervening type numbers having remained projects) was commenced, and this turned out a much more practical proposition. It was selected for immediate development as part of the R.L.M. Emergency Programme and given the official designation 109/509S2.

This second booster consisted of 109/509A2 and C components rearranged within a neat framework which hung below the wing centre-section, with two 600-litre tanks containing T-stoff fitted on the bomb racks. One of the internal tanks which normally carried "jet" fuel was modified to contain the C-stoff.

Complete in its mounting, but less cowling panels, the unit weighed 309lb.; the thrust it developed was reckoned to be 4,410lb., a figure that compared favourably with the rating of the main chamber of the 109/509C.

The external tanks could be jettisoned once they were drained, but it is not clear whether this applies also to the booster unit.

It would seem that a great deal of faith was placed in this prototype installation, and it remained on the emergency programme until the end; bench tests had, in fact, only just commenced when the Walter factory at Jenback was overrun by Allied troops in April.

Walter's Best Rocket Engine

The Heimatschutzer IV was expected to be the most efficient of all the rocket engines that Walter produced. It was by no means a makeshift unit as the "S1" sub-type, and, despite the urgency of its production, a great deal of prior consideration had been given to improving performance and *accessibility*.

The value of accessibility in fighter aircraft was made all too clear to the Germans during the "Battle of Britain." If in nothing else, the Luftwaffe pilots must have been amazed at the seeming large numbers of British fighters which, wave after wave, came up to engage them—fighters that their intelligence officers had told them were virtually non-existent. And yet "the few" it certainly was! The secret was in the speed at which the machines could be re-armed and refuelled after landing and then immediately returned to the fray.

What may be termed "ground speed" is designed into a fighter by the provision of convenient access panels, quick-release devices on gun-loading doors, fuel fillers, etc., just as air-speed is obtained by streamlining against air resistance. In fact, so strong is the case for accessibility that *miles per hour* have often to be sacrificed in order that time taken in servicing may be cut down by a few minutes. The rocket-adapted Messerschmitt 262 was an excellent example of this, for the suspended booster must have impaired the aerodynamic efficiency by no small degree; but it *did* allow the combustion chamber to be flushed out quickly and otherwise serviced and refuelled after use with the least possible delay.

Design Features

The control system of this engine differed from those of all previous production units in being *mechanical* instead of pneumatic operating. There were two elements governing combustion, one operating the propellant flow and the other, linked to it, controlling the steam supply to the turbine in sympathy with the thrust. An electric motor geared to the turbine shaft made the engine self-starting.

Another new feature was *combined* T-stoff and C-stoff injectors which were introduced into the combustion chamber to overcome the bad atomisation that had been present in all previous Walter engines when operating at low thrust. These were divided into three stages and were cut in progressively by the control unit.

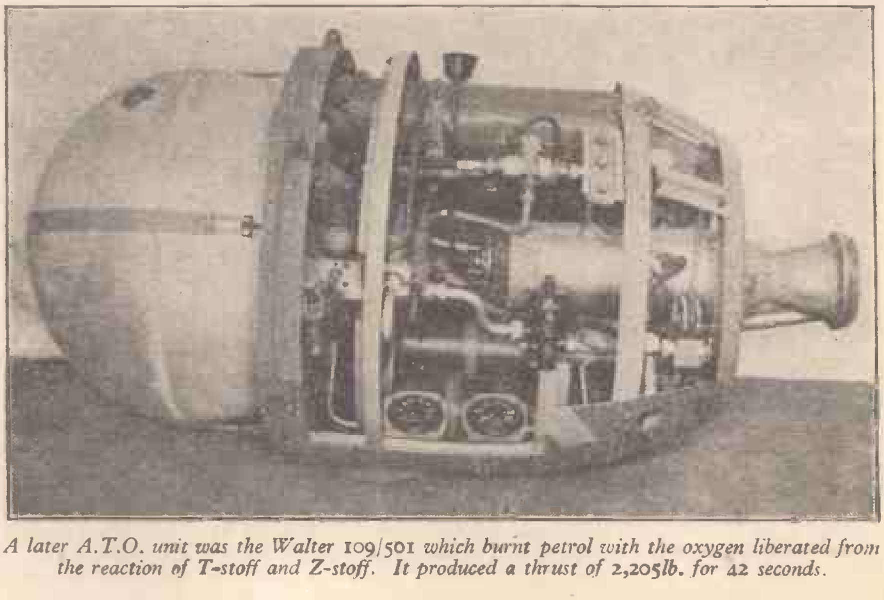
The steam generator was also subject to redesign, though there was no fundamental change.

More Engines of the 109/509 Family

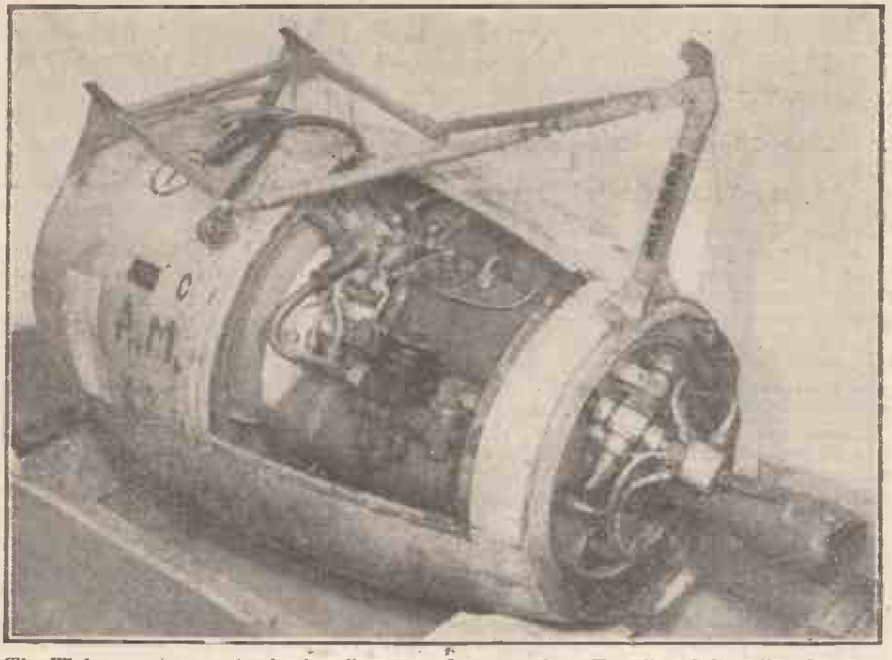
Finally, a word about the other rocket engines which were adapted from the basic 109/509A1 and "A2" units. The next positive step after these was the production of a "B" version having two combustion chambers, one normal size and the other smaller for economical "cruising." It was originally thought to be the "A2," but this sub-type has since been verified as being a simple development of the first production engine, in which the electric starter had been eliminated in favour of a gravity feed T-stoff starter. The 109/509B was a far more ambitious venture and should have replaced the "A2" version on Me.163s about the time of the surrender.

A second unit embodying two chambers was built specially for the Ju263 and was rated to produce a thrust ranging from 220 to 4,400lb., plus an additional 880lb. constant from its cruising chamber. This was the 109/509C.

The sub-type "D" employed exactly the same components as the "A2," but, whereas the latter had a single engine frame, the former was divided into three main assemblies—a pump and control group, combustion chamber, and connecting pipes. It was specially developed for the D.F.S.228 reconnaissance aircraft (see PRACTICAL MECHANICS, May-June, 1947, p. 266), and the perform-



A later A.T.O. unit was the Walter 109/501 which burnt petrol with the oxygen liberated from the reaction of T-stoff and Z-stoff. It produced a thrust of 2,205lb. for 42 seconds.



The Walter 109/500 assisted-take-off motor. It operated on T-stoff and Z-stoff and gave a thrust of 1,200lb. for from 24 to 28 seconds.

ance was precisely the same as the "A2," despite an increase in weight of 220lb. over the original 353lb.

A "Utility" Rocket Engine

Last in the 109/509 series was a "utility" engine for use in production Ba.349 "Natters." Initial work on this unit was carried out on a standard "A2" engine which, in modified form—the components simply having been repositioned to suit the new airframe—became known as the 109/509A2E. Again, the same performance as the parent was maintained, as also, on this occasion, was the weight.

Tests with this prototype engine were started in the autumn of 1944 and an order for 15 experimental units to a much simplified design (i.e., with an uncooled combustion chamber, a simplified pump and control arrangement and without electric starting) was placed with Walter shortly afterwards, only to be cancelled in February, 1945, by which time the war had become so desperate for Germany that all but the most outstanding projects—and out of these only the ones likely to be perfected quickly—were dropped. The Walter boost rockets and certain guided missiles were all that remained.

The "utility" engine received the designation 109/509E and would have had a controllable thrust reaching its maximum at 3,750lb.

Rocket-assisted Take-off

There were almost as many different versions of bi-fuel A.T.O. rockets produced by the Walter factory as actual propulsion units. A prototype motor known as the R.1.201 was tested as early as 1937, and a larger and more powerful unit, the R.1.202, was put into mass production late in 1940. Some 6,000 complete motors were eventually constructed, but, as it turned out, there was never really sufficient justification for them, and most eventually found their way to the scrap heap. The R.1.202 involved a considerable amount of maintenance and servicing after use, and with the successful application of dry-fuel rockets for take-off it soon fell into general disfavour.

First tests, all more or less successful, were carried out on four different aircraft, a Ju.88, a He.111, a Bv.138 and a Do.18. The units were attached to the wing undersurface, two, four, sometimes as many as eight being fitted; each could be jettisoned after the thrust period, and a parachute was embodied to ensure safe contact with the ground. After collection by the airfield personnel, they were flushed out with water to prevent corrosion—any damaged components being replaced—and then stored away for further use.

When approved by the R.L.M., the production unit was given the designation 109/500. The installed dry weight was 270lb., and the combustion of 23.8 gallons of T-stoff and 1.033 gallons of Z-stoff resulted in an average thrust of 1,200lb. which lasted for from 24 to 28 seconds. The propellant components were forced into the combustion chamber by air pressure, the permanganate decomposing the T-stoff to steam and oxygen at 480 to 500 degrees Centigrade.

More Powerful Assist-units

Despite the poor reception which had been accorded to Walter's "cold" units, research continued towards perfecting a more powerful bi-fuel motor, one capable of assisting really heavy aircraft, bombers, transports, troop-gliders and flying-boats, for which purpose normal dry-fuel rockets would have been grossly inadequate.

The first of the new motors was actually a development of the R.1.202, with certain modifications to enable oxygen, liberated in the reaction of T-stoff and Z-stoff, to be burnt with added fuel. This naturally meant higher combustion temperatures (in the region of 1,900 deg. Centigrade), and much time was given to the design of a practical coolant system. In the end it was found necessary to pass the T-stoff through a jacket around the combustion chamber before feeding it to the injectors.

The developed motor was known as the R.1.203, and in R.L.M. acceptance trials it proved capable of maintaining a thrust of 2,205lb. for fully 42 seconds, having a specific consumption of almost half that of the former model. It was afterwards given the designation 109/501. The overall weight of the propulsion unit was 1,208lb., including 485lb. of T-stoff, 25lb. of Z-stoff, and 42lb. of petrol which, as the secondary fuel component, was also fed to the chamber by air pressure. A small amount of hydrazine hydrate was employed to initiate combustion.

The R.1.210 was another bi-fuel A.T.O. unit, a development of the R.1.203, in which the size of the metering orifices was the sole difference. The result was an increase in the thrust to 3,307lb. and a reduction of the firing time to 30 seconds.

The R.L.M. type number allotted to this motor was 109/502 and, as far as is known, it was the last production example of the Walter assisted-take-off series.

There are, of course, many examples of dry-fuel rockets in regular use with the various air forces, but whether or not Walter type R.A.T.O.G. will reappear as more powerful and longer sustained thrusts are required remains to be seen.

The foregoing concludes the section dealing with rocket propulsion for aircraft, leading now to the story of Peenemunde and the development of German long-range rockets, the winged V-2 and the 98-ton transatlantic rocket with which it was planned to bombard New York.

(*To be continued*)

Items of Interest

A Neat Conjuring Trick

WOULD you like to be able to walk up to a table covered with glasses, seize a large jug of water and pour out any colour desired by the audience? What do you say? "Yes, you would." Right! In the first place you can let people bring their own jugs and even supply water if necessary, for all that is required are a few drops of aniline dye in various colours and a reel of dark cotton.

Choose thread, if possible, which is not shiny. You will remember that matt surfaces absorb the light and do not reflect it to people's eyes. Tie a piece of cotton across the room, with other pieces about 1ft. long joined to it at intervals of, say, 2ft. At the end of each short piece, tie small knots and dip each knot into dye of a different colour. As you take the glass in your hand you must casually hold it so that one of the knots with the desired colour is inside the glass. As the water is poured in, it promptly turns to the required shade without the audience seeing the cotton or having the slightest idea of how your extreme cleverness is simulated.

Cheap Light

LIGHT is probably the most important commodity of civilisation. Its efficiency seldom exceeds about two per cent. What will engineers think of us in the future? They will say we are savages and they will be right.

The latest plans are interesting, for it is cheaper to produce light outside the wavelengths of the visible spectrum. Naturally, this would be little use, for it would show objects in the queerest of colours; different, quite different to those to which we have been accustomed by centuries of sun.

This does not daunt the lighting expert who now produces cheap, invisible light and causes it to make substances glow or fluoresce. That is how a great deal of this tubular light is accomplished, although it still is less convenient than the friendly glow-worm.

Glow-worms are really beetles, and it is not yet known if the beetle switches on its lights to please itself, or for what modern novelists call "sexual emulation." It can control it, however, and often the tap of your foot upon the ground causes a blackout. Glow-worms are far more efficient than any man-made light.