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A REMOTE-CONTROLLED MODEL TANK

NEWNES PRACTICAL MECHANICS

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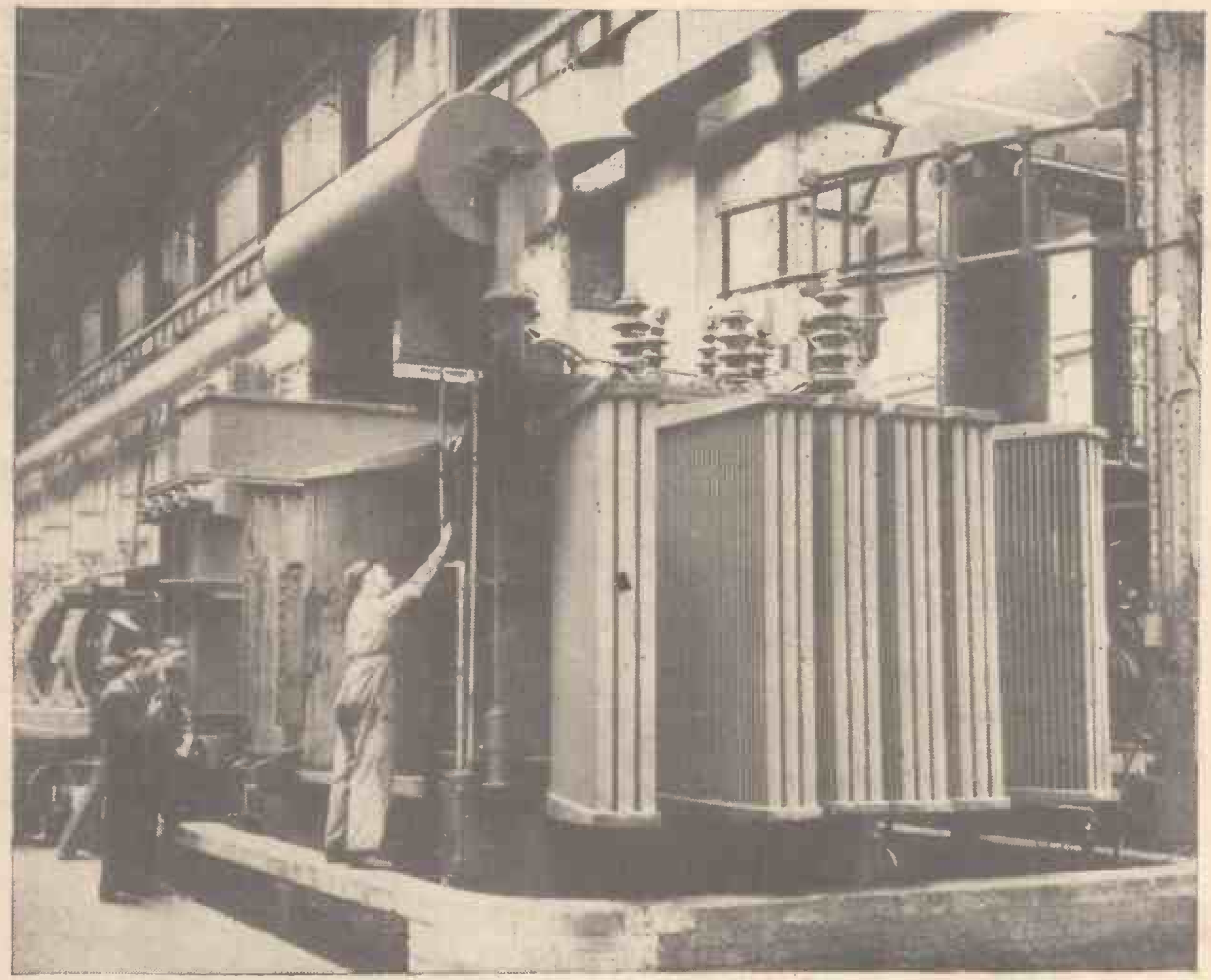
EDITOR: F. J. CAMM

FEBRUARY 1947



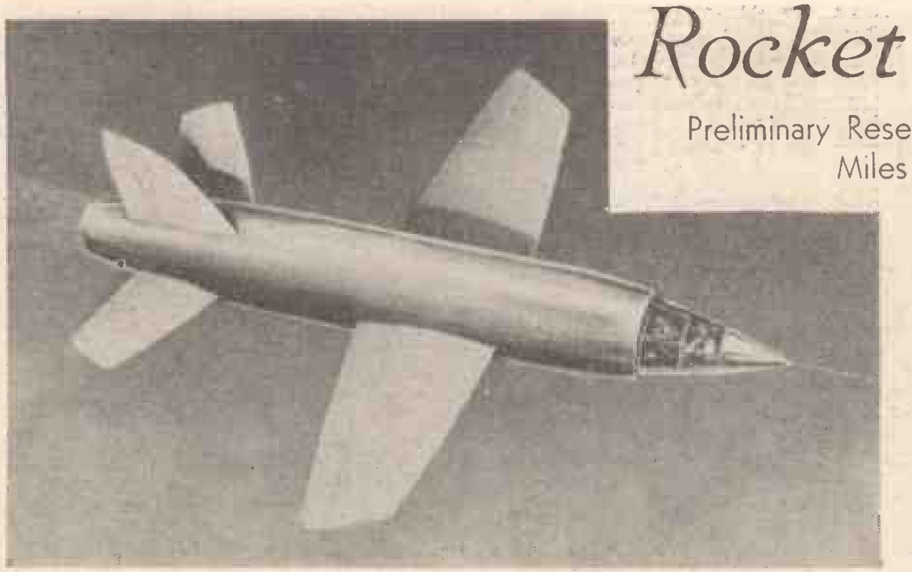
A BRITISH-MADE 7,500 kVA TRANSFORMER FOR RUSSIA (*See page* 155)

Rocket Propulsion

Preliminary Research With the "Natter": The Miles Trans-sonic Project

By K. W. GATLAND

(*Continued from page 129, January issue*)



An impression of the completed prototype, M.52, designed to reach 1,000 m.p.h. in level flight at 36,000 feet and climb to that height within one and a half minutes.

It will be recalled that an exhaust-vane system, working in conjunction with tail-plane elevons, was the control arrangement finally adopted in the Ba.349 "Natter." The reason was that in spite of an initial acceleration of about 2g., the speed at which the machine climbed from its launcher was generally no more than 35 m.p.h., and hence, the airflow over wing and tail during the period contributed little to control and stability. The condition was further aggravated by the rearward position of the c.g. when the A.T.O. rockets were mounted at the tail; actually as far aft as .60 of the wing chord.

To offset the instability which had been observed during early tests of the BP-20 prototype, auxiliary surfaces one metre square were attached by means of explosive bolts to each tip of the tail stabilisers, and these were blown off simultaneously with the dropping of the spent take-off rockets. This modification temporarily increased the tail-span to 14.8ft.

After jettisoning, the c.g. moved forward to between 18 and 25 per cent. of the chord (depending upon the amount of fuel and armament) and the remainder of the flight was invariably well stabilised.

Exhaust-vane Stabilisers

In order that the two conditions should be properly investigated, a proportion of the trial launchings was made with auxiliary tail-tips and part without.

These tests, however, were greatly hampered by the inefficiency of the Schmidding boost rockets: explosions resulting in the total destruction of aircraft were not infrequent, and the firing duration of those rockets which acted varied by as much as 100 per cent. from charge to charge. A few of the ascents were nevertheless successfully carried out, and although the increased tail-area did steady the near vertical climb, Bachem and his technicians were not entirely satisfied.

It was H. Bethbeder—credited as co-designer of the "Natter" with Bachem—who suggested the exhaust-vane system, and this would have displaced the tail-tip gear had the machine gone into service. Two vanes were fitted in a test machine, and these interconnected with the tail elevons so that—for instance—a pulling back on the stick raised both air-stream and gas-stream controllers. The significance of this arrangement, however, was when the machine flew under the control of an auto-pilot, for in the almost vertical climb, any deviation from true course would automatically bring about a corrective movement of the controls and a return to the original flight path

In the early stages of the ascent, as previously stressed, the air flowing over the wings and tail was moving relatively slowly, and this gave the air-stream controllers little opportunity for proper function. The gas-stream, on the other hand, was always fast moving, and thus the thin metal vanes set in the exhaust were effective both at high and low forward speeds, so long as the engine continued to function. At least this would have been the case had it been found possible to construct the vanes with sufficient durability, but despite hollow construction and internal water cooling, they invariably burned up and disappeared after the first 30 seconds of flight.

This should not be taken to imply that exhaust stabilisers could not be built with improved reliability. The experiments which Bethbeder conducted were necessarily hurried, and there is little doubt that given time for development a liquid cooled system could be made to work effectively throughout the full thrust period.

The Auto-pilot

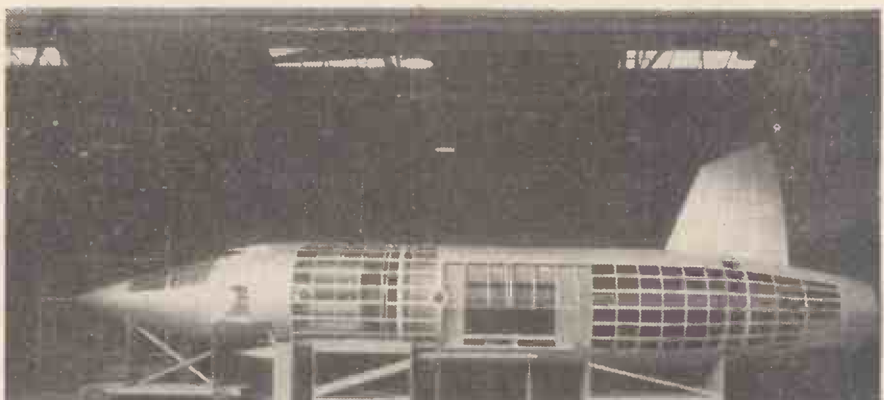
Another fault in the initial testing of the "Natter" was that the three-element auto-pilot was unreliable, and in the few flight tests made with the device the elements would not properly synchronize, with the result that ascents were erratic and far worse than in earlier launchings, when the controls were simply preset and locked.

In the majority of test-flights, small aileron-type tabs were fixed to the wings, so that the 'plane executed slow rolls during the climb above some 650 feet, when an altitude of about 9,000 feet was usually attainable.

Glide-testing the "Natter"

Some interesting data were forthcoming when glide tests were conducted. A BP-20 was ballasted to a gross weight of 3,750lb., with the c.g. at 25 per cent. of the chord, and towed to an altitude of 20,650 feet by a Heinkel He. 111. It was then released, and in the time available for glide before the pilot baled out, the following characteristics were noted: that (a) Stability was excellent and controls light and well co-ordinated for indicated air-speeds between 125 and 440 m.p.h.; (b) There was no rolling moment due to sideslip, and no apparent yawing moment due to the differential deflection of the elevons to produce roll; (c) The rate of roll was estimated at one revolution per second; (d) At 250 m.p.h. a full circle could be turned in approximately 20 seconds; (e) The controlled stalling speed was 125 m.p.h. indicated air-speed, which occurred at an angle of attack of about 30 degrees; and, perhaps most significant of all, (f) that the handling and flying qualities were judged by the pilot to be *superior* to those of any of the standard German single-seat fighters.

This particular flight might well have ended in disaster, for when the pilot operated the break-up control in order to gain his exit from the aircraft (which should have detonated the explosive bolts and released the complete nose section) it failed



This full-scale mock-up of the Miles M.52 shows clearly that most of the fuselage space was to be occupied by the special power jets engine and augmenter.

to work, and he had to battle his way out through the cockpit enclosure.

Although the release functioned smoothly in two earlier unmanned glide tests (when the gear was worked by a timer) it was not 100 per cent. reliable, and on later models was replaced by one having a purely mechanical action.

Miles Trans-sonic Development

It is now opportune to investigate the Miles M.52 project aircraft, for although the contract for the full-scale machine was cancelled in February, 1946, its form design remains in the Vickers rocket-powered research model now undergoing flight tests. A great deal has been heard lately of these experiments in which, it will be recalled, the aim is to penetrate the "sound barrier" in level flight, and therefore no apology is offered for including details of the interesting "jet" aeroplane which led to its development.

The decision for Britain to build a piloted aircraft for free-flight research at trans-sonic and supersonic speeds was taken by the Air Ministry in 1943. It was well known at the time that German aerodynamicists were advanced in similar projects, and for that reason no time could be lost in meeting the possible threat of "faster-than-sound" fighters and bombers from across the Channel.

The "flying-bullet" is an apt name for the Miles project. Its design was the outcome of extensive calculations governing the flight of shells and bullets and of research with special laminar flow "bi-convex" wing and tail sections.

The Project Stage

Armed with as much data on ballistics as they had been able to obtain, the Miles project engineers set about the task of shaping the fuselage. A three-stage jet engine and its fuel would obviously take up most of the space and naturally largely governed the cross-sectional diameter and length. The rest was a matter of suitably refining the shape to involve minimum resistance and to provide a cabin and suitable intakes for the engine.

Meanwhile, other technicians whose job it was to investigate wing form were busy with their own calculations and research, carefully refining out a special bi-convex aerofoil, strong yet thin and knife-edged for travel through the trans-sonic zone while embodying reasonable slow-flight characteristics.

The technical difficulties were immense, but with a basic pattern finally evolved, the next step was the construction of a complete model for wind-tunnel tests. This phase of the proceedings was the one in which the theories and calculations were put to a thorough check. Fortunately, only a few minor alterations were necessary to pass the shape as satisfactory, and the project was soon ready for handing on to the general design offices where the work was carried on in detail.

The bullet-like lines of the M.52 are well displayed in this model of the Miles trans-sonic project.

Not only had the Miles technicians virtually to formulate a new aerodynamical theory but they had to devise a control system fully workable in the subsonic register, but equally effective when flying in the region of the trans-sonic and above. It was also necessary to furnish the pilot—placed in the aircraft's pointed nose—with an automatic means of escape in the event of emergency.

A moveable tail-plane was provided for maintaining trim during flight at the various speeds because, under certain conditions of flow, the normal trailing-edge type control ceases to function satisfactorily. The arrangement was tested at low speeds on the Miles "Gillette" Falcon, described in the previous article and illustrated on this page.

The main-plane, 27 feet in span and mid-set on the 33 foot fuselage, is the thinnest cantilever wing structure ever attempted. A set of dive recovery flaps only 3in. deep and 12in. long were to be fitted on the undersurface.

The materials used in the construction of the airframe and wings were naturally of much higher strength characteristics than usually employed; a high-tensile steel structure with a heavy gauge high-duty alloy as covering.

The Power Jet W2/700 plus No. 4 Augmenter

The power plant—23ft. long and 3ft. 6in. in diameter—was designed and built by Power Jets (Research and Development) Ltd Its rated power is the equivalent of 17,000 b.h.p., but as will be seen, this was substantially improved by the incorporation of a ducted fan and augmenter.

There are three stages, the first consisting of an orthodox jet unit with centrifugal blower and turbine, the latter serving an additional purpose (stage two) as a ducted fan, bringing in a separate supply of air through intakes placed just behind the main annular air-scoop. The air from this source is then mixed into the main "jet" stream which flows on through a length of ducting where supplementary fuel burners are placed. In this third "augmenter" stage, further expansion (and hence, acceleration) of the stream takes place before its final ejection, thereby adding materially to the thrust of the basic engine.

A special tubular structure provides mounting for the engine and also secures the cabin.

The Control Cabin

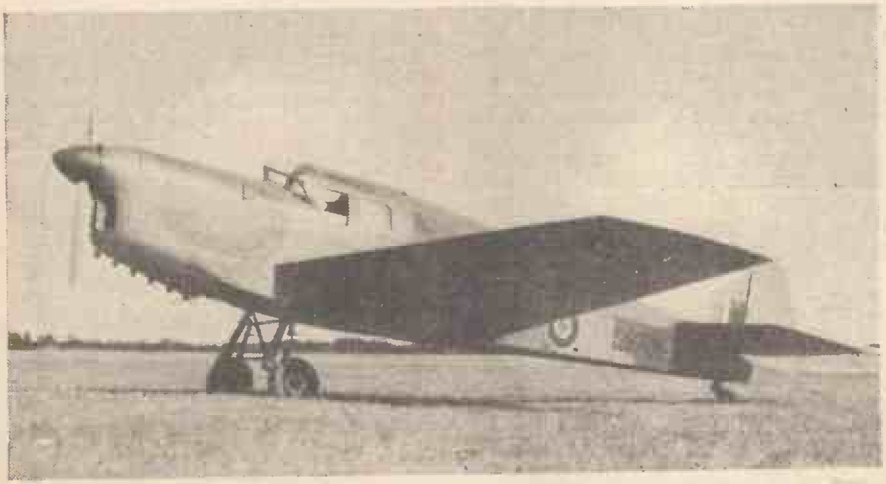
It was anticipated that testing should begin at 50,000 feet altitude and the cabin was pressurised to provide for this.

The seat for the pilot was placed directly upon the cabin flooring and his feet raised above floor level, the nose wheel retracting into a housing between them.

The controls were naturally servo-assisted. The expected control loads on the M.52, said Mr. Miles, were approximately 100 times greater than those experienced on even the largest of present day aircraft. And yet, despite the small size and great weight of this machine, it was expected to be easily manageable both at high and low speeds. The all-up weight was calculated to be about 8,200lb. at take-off, with a wing loading of 58lb. sq.in., and this implies a high landing speed; 170 m.p.h. with a two-mile landing run were the figures quoted. Special tyres and wheels, in fact, had to be designed to withstand the shocks involved.

Emergency Escape

To allow the pilot a reasonable chance of survival should any mishap occur during testing, the complete nose-section was made detachable, its release to be effected by means



The Falcon "Gillette." With this machine it was possible to test the slow-speed qualities of the special wing and tail-plane developed for the M.52.

of cordite charges which would blow the cabin (with pilot still housed within) clear of the aircraft. Cleats filled with the explosive were to be fixed to the cabin supports which would be sheared by the touch of a button. A large parachute, packed in the rear end of the cabin, would then automatically open and bring the speed down to a safe value for the pilot to bale out in the normal manner.

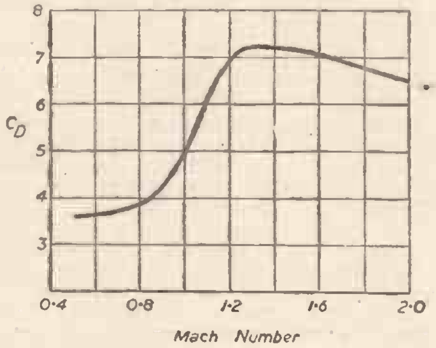
Recording Equipment

The aircraft having its sole purpose in research, many of the instruments had to be specially developed. The micro-observer, for instance, was intended to measure and photograph electrically all the readings required, this with the aid of sensitive Tinsley galvanometers on which there were 24 separate readings. Another special apparatus was a cathode-ray oscillograph to measure the strains produced in certain fundamental positions of the structure, photographing the results.

A full complement of 18 instruments, in addition to a transmitting compass and oxygen control, would have furnished complete data of flight conditions through the "sound barrier," and as the whole would be registered on film, the pilot had no other concern than control his aircraft. In the past are the days when test pilots grappled with knee pads, hurriedly scribbling down instrument readings with one hand while endeavouring to maintain control with the other.

Contract Cancelled

The reason why the contract for this enterprising machine was cancelled when the detail design was 90 per cent. complete, with all assembly jigs finished and component assembly well under way, the engine ready for installation in the airframe, is officially stated to be "economy."

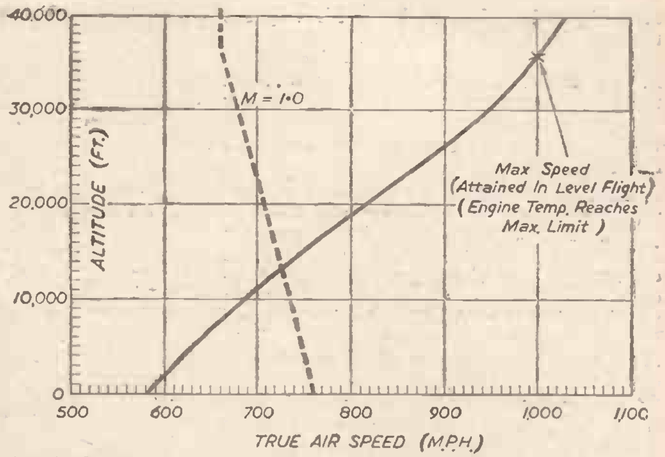


The aerodynamic "curve of fate," showing how drag increases in travel through the trans-sonic zone.

Not a particularly convincing explanation this, especially in view of the obvious military importance of the development—unless, of course, the design is outmoded by recently acquired technique. The athodyd, for example, was virtually unknown at the time when the M.52 specification was drawn up (now nearly four years ago), and hence an athodyd research aeroplane might well be on the stocks "somewhere in Britain."

From the purely aerodynamical standpoint, the design compares favourably with the best the Germans had to show, although it is true that the Delta flying-wing layout (and wing sweep-back in general) was coming into prominence, and again this may have sufficient justification for abandoning the Miles venture.

Whatever may be the true reason for that vital decision, it must have come as a bitter blow—and one entirely "out of the blue"—to F. G. Miles and his design staff, pioneering as they were in an entirely new field of development. There is no doubt that an aeroplane such as the M.52 is a much needed item of equipment at the present stage of research, which could provide answers to innumerable aerodynamical problems. It would pave the way to the immediate development of aircraft capable of supersonic speeds, as fighters, mail and passenger transports—and although the spirit of the Miles project lives on in the Vickers trans-sonic model, there is a whole lot of difference between shooting off pilotless models through that perplexing zone of speed and actually *experiencing* trans-sonic conditions.



Graph showing maximum speed of the Miles M.52 with power jets W2/ 700 plus No. 4 augmenter.

The Vickers models will help. Of that there is no question, but they can only be supplementary to a manned research aeroplane. Whether this can be taken to imply that work on the M.52 will at length be recommenced, or that another research aircraft is taking shape behind the guarded curtain of security, it is impossible to say. But that the work so successfully undertaken at the Miles Aircraft, Ltd., has provided unparalleled data on the theory of trans-sonic flight and of the formidable constructional and installatory problems involved is unquestionable; a genuine credit to British design.

(*To be continued.*)

Mathematics as a Pastime—2

The Square Root Emerges.

By W. J. WESTON

GET your ruler to measure lengths, your set-square to set out a right-angle, and your compass to cut off lengths.

You know that x^2-y^2, the difference of two squares, is resolved into the factors $(x+y)(x-y)$, the sum of the numbers multiplied by the difference of the numbers: (99^2-98^2) is $(99+98)(99-98)$, that is 187. You can, therefore, express any number whatever as the difference between the squares of two numbers that differ by one. Thus:

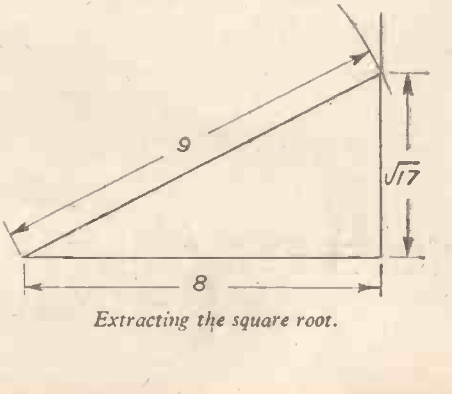
9 is (5^2-4^2), that is $(25-16)$,
17 is (9^2-8^2), that is $(81-64)$,
20 is $(10\frac{1}{2}^2-9\frac{1}{2}^2)$, that is $(110\frac{1}{4}-90\frac{1}{4})$.

You know, too, that the square on the side opposed to the right-angle of a right-angled triangle equals the sum of the squares on the two sides containing the right-angle.

Well, to lighten your work, apply those truths. For it is not the finding of a thing, but the making something of it when it is found, that is of consequence.

Suppose you want the square root of 17, for example, of (9^2-8^2), that is. Draw your horizontal 8 units long (centimetres are convenient as the units). Erect a vertical at one end of the line. With a length of 9 units in your compass stretch from the other end of the horizontal to the vertical.

Read off your upright; if you have worked with care, you find that $\sqrt{17}$ is slightly more than 4 centimetres and 12 millimetres, slightly more, that is, than 4.12. Test the matter by finding the square root in the traditional way—that is, by applying the truth $(a+b)^2=a^2+2ab+b^2$.



Extracting the square root.

$\sqrt{17}$:

$$\begin{array}{ll}
 & 17\,(4.123 \\
 & \underline{16} \\
81 & 100 \\
 & \underline{81} \\
822 & 1900 \\
 & \underline{1644} \\
8243 & 25600 \\
 & \underline{24729} \\
 & 871
\end{array}$$

We find the nearest square below 17: this is 16, of which 4 is the square root. Our a then is 4 and our a^2 is 16. The 1 remaining out of 17 must, therefore, be $2ab+b^2$; and, by inspection, we find that b must be 1. For $(8+.1)\times.1$ is .81. So we proceed, taking as a the part of the root already found, and finding b by inspection.

Of course, you remember that the interpretation of two consecutive digits like 42 differs from the interpretation of two consecutive letters like ab: the first is 4 tens+2 units, the second is $a\times b$. If a is 4, and b is 2, then ab is 8 and not 42.

That this result is accurate enough you will see by reversing the process: that is, square 4.123:

$$\begin{array}{r}
4.123 \\
\underline{4.123} \\
12369 \\
8246 \\
4123 \\
16492 \\
\hline
\underline{\underline{16.999129}}
\end{array}$$

This is as near to 17 as makes no matter.

(*To be continued.*)