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THE MALAYAN TRIALS OF THE WS A510
(Tests on laboratory Models in April 1952)

By

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1. GENERAL

The purpose of these trials was to assess the A510 in an area where not only tropical conditions existed but also where a military action was actually taking place. The aim was further to show the equipment to members of the British Army and receive criticism based on their first hand knowledge of requirements in that area. Further, apart from the A510 itself, it was expected that the general knowledge gained would be of great advantage in the design of future equipments.

The party consisted of Lt.Col.D.Small (Department of Supply), Major R.P.Woollard (Directorate of Signals), and Major R.Coutts (Directorate of Infantry), together with K.G.Dean and L.K.Curran as civilian observers representing A.W.A.

It was much appreciated by the A.W.A. members that although we were two civilians of a military party, in military surroundings, we were at all times treated as two members of an Australian party of five, whose purpose was to test and demonstrate the equipment which we had brought with us. From our point of view, our greatest disappointment was the restrictions placed on our movements in Malaya. Australian Military headquarters had specifically stated that the civilian members were to be permitted to go only into safe areas. As bandit activity exists over the whole of Malaya this was interpreted by G.H.Q., Singapore, to mean that we were free to move only on Singapore Island itself and in the camp area of the Farle Training Centre, (F.T.C.), 25 miles north of Singapore, in the country around which most of the tests were carried out. This did not permit us to see or make any technical assessment of primary jungle from the point of view of aerial erection or propagation conditions, although we had assumed that this would be one of our important tasks.

On the other hand, much was learned from people we met at the F.T.C. The F.T.C. is a centre where not only are troops trained for the jungle action in Malaya but where the staff has an intimate and detailed knowledge of the conditions existing in Malaya. A general background of ideas on requirements and limitations of communications equipment was obtained, not only from officers, but also from N.C.O.'s and signallers. Although most of the information was obtained from direct technical discussion, the very contact with people of experience in the jungle often provided, indirectly, just as important information. For example, the story of a training patrol left in the jungle for two days without rations expected from an air drop, because the signaller had rendered his wireless useless by leaving it switched on and allowing the batteries to run down, was a rather forcible reminder that all equipment needs to be as foolproof as possible.

At the F.T.C. we were permitted to see demonstrations of tactical and signals methods used in the jungle. Having stressed the need for maximum efficiency of aerials when used

with small sets, it was of great interest to find that it was the practice in Malaya to do everything possible to get the most out of the aeriels used, even to the extent of spending an hour (after a day's trek through the jungle fully loaded with gear) in clearing the scrub around the aerial site.

The tests were usually carried out with one A510 at the F.T.C., set up as base-station, and one or two A510 sets mobile in the surrounding jungle or rubber areas. Tests were carried out using both sky-wave and ground-wave conditions with both long wire and whip aeriels, and comparisons were made with the WS68 which is the set currently used in Malaya. Although the 68 set is probably equal or better than the A510 in power and radiation efficiency, it proved at most times to be inferior in operation to the A510, because of the 68'set's lack of stability, the difficulty in netting it with other sets, and because of the time it took to get it tuned and "on the air."

The A510 also has a marked advantage over the 68 set in weight and shape (form factor). The comparative weights of the A510 and the 68 are respectively 16 and 34 pounds. Demonstrations and tests were carried out with the A510 carried on a soldier who was also loaded with his other gear (ammunitions, weapons, rations, etc.). When the A510 is mounted on the chest in two basic pouches (the normal mounting position), the complete load enabled the man to stand erect in a comfortable position (see photograph 4): The 68 set is strapped with the rest of the soldier's equipment on a standard metal carrier (left hand of soldier in photograph 4), which is mounted on the back. With this method of mounting and the additional weight of the 68 set, (the total weight then is 70 lbs.), the soldier must lean forward to maintain balance and it is difficult to walk without swaying. In order to satisfy some who preferred all the equipment to be mounted on the back, it was demonstrated that the A510 could also be fitted very neatly onto the standard carrier (photographs 3 & 5).

Demonstrations were also given of a soldier fully loaded with gear, plus the A510 mounted on the chest, to show that he could go to ground and use his weapons whilst the A510 was in an operating position, including the whip aerial and loading coil being in place (photograph 2). Photographs of the equipments mounted on the soldier are appended to this report.

A one-day visit was paid to Kuala Lumpur where the sets were shown to the Headquarters staff and signals representatives from the operational brigades in the area. Unfortunately, a short demonstration was largely a failure, due to excessive electrical noise at the base station.

Whilst at Kuala Lumpur, an Army report was obtained on aeriels and propagation; this was based on operational rather than technical results. It is most interesting because, in spite of difficulties of erecting good aeriels in the jungle, the operational recommendations agree by and large with those made by us on purely technical grounds.

The D.S.I.R. ionosphere research station in Singapore was visited twice. It was of interest to find that a Thomas noise recorder had been installed some months previously. Readings are not interpreted in Singapore but are sent back to England for analysis. At the time of the first visit no results of the analysis were yet available, but since then the first results have been received and are now in the D.S.I.R. official (unpublished) reports on noise which can be seen in Australia. Also, the

ionospheric records which we were permitted to examine indicated clearly the unusual ionospheric conditions of that area, which has an important bearing on the choice of operating frequencies; these are rather lower than would usually be expected. Only a limited number of records had previously been found in the literature.

The R.E.M.E. (Royal Electrical and Mechanical Engineers) workshops at Singapore are well equipped for radio servicing and are air-conditioned. Discussions with the people there, on servicing problems and faults in military equipments, proved to be most profitable. It was of particular interest to note that failure of sealing in the 88 set, which has similar cases to those which will be used on the A510, represented only about 2% of all faults. The greatest number of faults was due to valves.

2. TESTS

The majority of tests carried out were listening tests and subjective ratings (strength 1 to 5) were given to the signals received at each end of the radio circuit. These, it is considered give only an assessment relative to the prevailing conditions of general background noise, both atmospheric and electrical. This is especially so as the receiver of the A510 has sufficient gain almost always to give adequate acoustical levels of output, particularly when long aeriels are used. It is considered that these figures give an overall assessment of the communications circuit. It was shown that the assessments by members of the Australian party agreed with those of signallers; further, that when strengths 4 to 5 were recorded, more than 80% of words, sent in random relationship, could be copied correctly.

Rather than being an assessment of maximum ranges achievable over a limited number of conditions, the tests were carried out to demonstrate that communications could be achieved speedily and under a wide range of conditions. Comparisons with the 68 set indicated not that this set was inferior in radiated power, but that the A510 was superior in simplicity of operation and stability.

The fixed A510 base-station at the F.T.C. usually had better aeriels, particularly for ground-wave working, than the mobile station. For example, generally when a whip was used for the out-station a long wire was used at base; however, a whip was at times also tested at the base station. Also, the area around the base station was either cleared or comparatively lightly covered for at least a quarter of a mile in all directions. The frequency used for ground wave working was generally 3.45 Mc. but, again, all other frequencies were examined. For sky wave working the frequency basically used was 6.45 Mc. as this was estimated as being the nearest to optimum of the frequencies available, but for this mode of propagation the other frequencies were also examined.

Under conditions of the base station as described, ground wave communications in both directions were achieved, with a whip aerial at out station and wire at base, for distances up to 5 miles or more when the intervening terrain consisted of rolling hills covered by rubber plantations. When the mobile station was mounted on a vehicle (thereby providing a better counterpoise for the set), two-way communication for distances of 6 to 8 miles was possible. When long wire aeriels were used at both ends, communications over distances of nearly 10 miles

were achieved. With a whip aerial at both base and out station distances greater than 3 miles were possible with this intervening terrain. The above distances are quoted for intelligible communication (above strength 3 on the subjective rating) and for a suitable low frequency 3.5 Mc. Less ranges or strengths were found for higher frequencies.

When the intervening terrain was covered by 3 miles of jungle and 5 miles of rubber, ground wave communication of low intelligibility, but sufficient to transmit the record of strength received back to base, was achieved.

For distances between 5 and 10 miles it is often possible to use, with equal effectiveness, either the sky-wave or the ground wave and when end-fed aeriels are used, it is difficult, at times, to tell which is the mode of propagation. It was possible to get some indication that the ground wave was being received by replacing one aerial by a whip, which ideally will receive no sky wave. Further, a serious increase in fading when dipoles (for the sky wave) were replaced by inclined long-wire aeriels indicated the presence of a strong ground wave as well as sky wave in the second case.

When the intervening terrain, except for the camp area, was covered entirely by primary and secondary jungle, a range of about 3 miles was achieved when a long-wire existed at base and a whip at the out station. For whip to whip working within the jungle a range of a little over 2 miles was achieved, but it is considered that this figure (2 miles) is rather optimistic and a safer conception of the range for the worst jungle would be a mile or less. (Note - it is difficult for us to discuss this point as we saw only partly the type of country involved).

It is particularly to be noted that the ranges obtained for whip to whip working in jungle were achieved only at the highest frequencies (6.5 and 9.5 Mc.). No exact numerical explanation can yet be given of this fact for a distance of 2 miles as sufficient knowledge does not exist of jungle attenuation nor has the actual radiated power of the A510 yet been accurately determined, but it should be noted that the original propagation estimations for the A510 for soil conductivities of 10^{-13} (good soil) and 10^{-14} (poor soil), indicated that for distances less than 1 mile higher fields would be expected for the higher frequencies. Further, it has been found experimentally that the aerial losses are often greater at the lower frequencies than originally assumed in the theoretical estimations and aerial coil losses are likewise greater. Three factors determine the relative ranges for different frequencies, viz, efficiency of whip aerial which increases with increase in frequency, the efficiency of the aerial loading coil which increases also with increase in frequency, and ground-wave propagation efficiency which is less at higher frequencies. Atmospheric noise during quieter part of the day should not be a limiting factor. For average terrain the third factor compensates for the other two. In one assumes for the jungle an equivalent conductivity of 10^{-15} E.M.U. the field strengths for all frequencies should be about the same at 2 miles neglecting the additional tuning coil losses at lower frequencies, and also neglecting aerial losses in addition to those originally assumed.

Radio/telephone sky-wave communication was maintained without trouble. The maximum distance achieved was about 26 miles but this distance is unimportant, as for sky-wave working there is no propagation difference for surface distances up to 50 miles

and little for even greater distances, the height of the ionosphere being 200 miles or more. The basic frequency used was $6\frac{1}{2}$ Mc., and when other frequencies were tried it was automatic that a return was made to this frequency, so that in spite of any failure on a less advantageous channel, contact was always maintained. The choice of this frequency for basic use appeared substantially correct but good results were obtained also with 5.2 and 4.2 Mc. and some contact, at inferior intelligibility, was made with a frequency of 3.5 Mc. and also at 9.9 Mc.

The fact that 9.9 Mc. was found to be inferior to lower frequencies is important, as without knowledge of ionospheric anomalies existing in the area, this is the frequency which would be chosen. It proved less useful because firstly, the effective height of the ionosphere is greater than at lower frequencies, and secondly, because of interfering stations and also higher atmospheric noise during the middle of the day.

For sky-wave communication during the day in Malaya, it can be said that satisfactory R/T results were obtainable for the period of the trials provided correct frequencies were used and, generally speaking, provided a dipole was used at one terminal at least, and preferably at both terminals. Although good results were, at times, obtained when inclined end-fed aerials were used at both ends of the circuit, this was not always the case.

A summary of the listening tests is included in the appendix.

3. MEASUREMENTS

Only a limited number of measurements of field strength were taken as the equipment used was too inflexible. As weight precluded taking an ordinary F.I. set to Malaya, an A510 was adapted for the purpose. This consisted of a receiver with output meter; for calibration the transmitter was placed at a known distance from the receiver (greater than 100 yards). A most interesting feature of the measurements taken was the low fields actually recorded, some of these being less than $1\mu\text{V}/\text{m}$. These fields are well below the capabilities of the Marconi F.I. Set. With fields of this order, intelligible signals were received even on a whip aerial, especially if an earth mat were used. This latter fact indicates to what extent the success of the set in Malaya has been due to the sensitivity of the receiver.

These measurements are recorded in the Appendix together with the subjective tests. A point of particular note is the increase of strength when an earth mat is used and when higher power batteries are used.

Measurements on noise were mainly carried out using a 6.5 Mc. dipole at the base station. The received noise was measured by using the adapted A510 receiver (with meter) and the substitution of a signal generator for the aerial determined the level of the input voltage. The dipole was used for convenience as it was already erected and there was no means for calibrating a vertical aerial. Further, there was no means for tuning an aerial on the adapted receiver and a cut dipole provided an aerial which virtually did not require tuning.

4. AERIALS

The importance of efficient aerials is well appreciated in Malaya where the most simply erected inclined aerial is not

recommended for the equipment there. All aeri-als used there are supported at two points and are mainly the inverted -L type. Such types could well be used with the A510, with the limitation that the A510 would not tune an aerial having a half-wave horizontal section and a vertical section less than a quarter-wave, which is the most promising type at present used in Malaya.

The dipole is, however, the best simple aerial of all and the A510 has been specifically designed to have maximum efficiency when feeding it.

In Australia, the dipole was never tried properly with the A510, it being regarded only as an aerial to be used when others failed. A previously cut dipole proved very effective in Malaya and easy to erect, and due to its use, it is considered that the sky-wave tests were far more effective. When dipoles were used, even at only one end of the circuit, better results were achieved than with end-fed aeri-als, provided the dipoles were sufficiently high. It is to be noted, especially when tests were specifically carried out, that a low dipole (5 - 7 ft say) always gave an inferior rating strength to a higher dipole (25 ft.) and usually inferior also to well erected end fed aeri-als. It should also be noted, however, that good communications did take place at times whilst the outstation was still erecting the aerial and on one occasion when the aerial was actually on the ground but an increase in receiver output level was always noticed as the aerial was raised.

6. THE EQUIPMENT

It is considered that the success of the trials in Malaya can be attributed to three aspects of the equipment, viz, (a) the high sensitivity of the receiver, (b) the simplicity of the transmitter tuning even with the present function switch which is difficult to use and is being replaced, (c) the general reliability of all parts of the equipment and its inherent stability. It is considered that had the equipment been sent to Malaya at a less developed stage, or after a more hurried development with consequent less attention to detail, the tests may well have been disappointing.

Three complete wireless stations A510 and one modified to serve as an F.I. set, were taken to Malaya. The sets were those used in the field trials at Balcombe, Victoria, in February. It will be recalled that as a result of the Balcombe trials many modifications were requested, the most important of these being the replacement of the function switch and a greater meter reading for tuning when using the rod aerial.

The equipments taken to Malaya were modified to give greater output indications but no other modifications were carried out, except that the preferred type loading coil was used on each. A new arrangement for the transmitter panel in which the function switch had been replaced by a much more convenient system had been designed before the party left for Malaya. A "dummy" front panel incorporating the ideas of the proposed new arrangement was taken to Malaya and shown at all the demonstrations of the equipment. The criticisms made by the user at Balcombe were repeated by their equivalent types in Malaya, although perhaps with not the same emphasis, as the signal personnel were prepared to accept some difficulties in their earnest approach to establishing communication.

Of the three equipments, two contained receiver units

which did not incorporate AVC, the third set containing a receiver with AVC. This latter set was the only one, therefore, which met the user requirements technically. The transmitter sections and interwiring was identical in each station.

At Balcombe the four equipments had worked throughout the trials without a fault occurring. In Malaya two equipments failed during the trial period, these being the receiver unit with AVC and the receiver unit modified to serve as an F.I. set. The failure in both cases was due to the effect of humidity on the i.f. transformers causing primary to secondary leakage due to inadequate sealing of the case to front panel and the omission of the sealing screws on the i.f. assemblies. This fault was not regarded with any seriousness as the present cases were not claimed capable of providing real hermetic seals, but it is significant to note that the receivers in which the I.F. transformers were sealed, gave no trouble. There were no other electrical faults and mechanical ones were only comparatively minor.

The receiver units were repaired at the very well equipped workshop of R.E.M.E. This workshop was very efficiently organised and included a large air-conditioned section containing screen rooms and an oven in which dry air was circulated. The repair on the two receiver units did not remain effective and these two units deteriorated again.

The operation of the sets in the jungle brought to light two unexpected difficulties and some modifications have been called for as a result. In the jungle perspiration from the operator is sufficient to shower the panels of the sets as though it were raining. This shower of moisture covers the window of the main tuning meter and impairs visibility to a very large extent. Heavy rain, which is a regular feature of the tropic areas, also has this effect. The first modification, therefore, is concerned with improving the viewing of the tuning scale. This information was passed back to the A510 team at A.W.A. whilst the party was still in Malaya and the modifications to design were well under way when the party returned.

The impaired visibility made the tuning of the whip loading coil much more difficult than it should have been. The Army representatives asked that an investigation be made as to whether the tuning was too coarse and to carry out any modification thought desirable. This information was likewise passed back to A.W.A. whilst the party was still in Malaya. However, it is probable that with an improved viewing arrangement the present tuning of the loading coil will be satisfactory.

The heavy perspiration and rain shower on the panel also showed that the aerial terminal did not provide adequate insulation. This information was also passed back to the A510 team whilst the party was still in Malaya and a new terminal should prove quite satisfactory, both electrically and mechanically. The terminals on the equipments had proved inadequate in the mechanical sense, both at Balcombe and Malaya.

The second important requirement brought to light was the necessity for some form of crash limiter. The severe local thunderstorm which occurred each afternoon in which a large burst of static occurred with intervals of 1 sec. to 1/5 sec, impaired intelligibility by overloading the ear. The provision of a crash limiter was one definite requirement not previously suggested. Since the return of the party an investigation has shown that there will be some difficulty in incorporating the limiter.

Slight modifications in the layout of controls were suggested by various people and these have been acted upon where possible. In general the sets were accepted and used in their present form with ease by all types of signals people. It was obvious, however, that the Balcombe request that the function switch be simplified was quite justified.

With regard to accessories, it was noted that the 3-wire earth system, for use with long aeriels, was cumbersome for jungle working. This had already been noted during the aerial investigations early in the development of the A510, and alternatives having the same efficiency were examined, and for one reason or another found wanting from an electrical point of view. The only answer seems to be to reduce the number of wires and accept the additional loss. Deterioration of the "shorting links" on the one-length end-fed aeriels occurred but this did not cause undue concern, as they had been prepared quickly in order to answer the criticism of the Balcombe trials that three separate aerial sections to be used in combination (as then supplied) are liable to be lost. The success of the dipole in Malaya calls again for an adjustable dipole as originally specified. The only way of achieving this effectively seems to be some form of roll-up spool. If such can be developed it could overcome also a major fault of the one-length long-wire aerial, i.e. that when a short aerial is required much of the height is often lost in the non-active sections.

It had been suggested before the Malayan trip that the set should be sealed in such a manner that it would not be possible to repair it in the field without special tools. It was noted that this is in fact being done with the WS68, in which a new case screw which breaks off when tightened sufficiently is being used. Also the dessicator cannot be replaced unless the unit is withdrawn from the case.

The WS.A510 compares favourably with the WS68 at present being used in Malaya. The technical figures for the sake of comparison are shown below:-

	<u>WS68</u>	<u>WS A510</u>
Frequency coverage	3 - 5.2 Mc.	2 - 10 Mc.
Power output	1 Watt in 75Ω	0.75W in 75Ω
Receiver sensitivity	4.0μV	1 - 3μV
Weight	34 lbs.	16 lbs.

CONCLUSIONS

The A510 proved itself to be a reliable and flexible piece of communications equipment under the conditions which it was required to operate in Malaya; it proved itself to be superior, in overall effectiveness, to the currently used heavier 68 set. Except for deterioration due to moisture in two of the sets, no new major faults were found. (This fault did not cause undue concern as it had not yet been possible with the hand-made cases to provide perfect hermetic sealing).

Faults, such as those of panel layout, etc. discovered in previous tests, continued to be evident. Some smaller faults were evident, (these are now being remedied), and methods of improvement suggested themselves and these are now being acted upon where possible.

From our point of view the novel arrangement of including civilians in the Army party was a success and much was learned by us of Army requirements and problems; it is thought that only benefit can result from continuing this arrangement and permitting A.W.A. people to be present at future trials.

We wish again to express our appreciation to the Army members of the party who, at all times, treated us as one of them.