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20th July, 1944.

WAR CABINET.

**SELECT COMMITTEE ON NATIONAL EXPENDITURE: REPORT ON
TANK PRODUCTION.**

NOTE BY THE SECRETARY OF THE WAR CABINET.

BY direction of the Prime Minister I circulate herewith for the consideration of the War Cabinet—

- I. A draft letter to Sir John Wardlaw Milne prepared by the Minister of Production, the Secretary of State for War and the Minister of Supply.
- II. A Memorandum, prepared by the same Ministers, as an enclosure to I.
- III. Summary of Reports received on the Performance of British Tanks.

The first two documents take the place of those contained in W.P. (44) 262 (pages 22-30). The draft letter has been completely revised; the Memorandum has been amended, the alterations from the version contained in W.P. (44) 262 being side-lined.

(Signed) E. E. BRIDGES.

*Offices of the War Cabinet, S.W.1.
20th July, 1944.*

I.—DRAFT LETTER FROM THE PRIME MINISTER TO SIR JOHN WARDLAW-MILNE,
K.B.E., M.P.

(Secret.)

I wrote to you on the 25th May concerning the Memorandum of your Committee about tank production. Since then the Cabinet have been able to consider the Memorandum, and the conclusion we came to was that although a good deal of the ground which it covered had been traversed during the Secret Debate in the House of Commons on the 24th March, the interest which your Committee has taken in this very important subject merited a reply more particularly directed to their findings and recommendations. I have accordingly had the enclosed document prepared for the information of your Committee.

There are one or two general observations which I wish to make. Satisfactory American tanks were available in adequate numbers during 1943, and British troops were not engaged in large-scale tank operations after the Tunisian campaign. These two factors removed, for the first time since Dunkirk, the fear of a quantitative deficiency which had previously prevented development of tank design and production on the lines we should have followed had we been free to do so. The situation in 1943 enabled a drastic reshaping of our tank production policy, and this accounts in large measure for the fact that 1943 output fell substantially short of the estimate made at the end of 1942.

The Minister of Production, the Secretary of State for War and the Minister of Supply have, during 1943, kept jointly under review the working of the new organisations which were set up at the end of 1942, and are satisfied that they are functioning efficiently and smoothly. The Ministers have advised me that in their opinion it would be unwise at this stage of the war to hand back to the War Office the responsibility for obtaining the production of all technical stores including tanks. I agree with them that such a major reversal of policy at this date would not be practicable or justified by anything that has happened in the last eighteen months. This is a matter of long-term policy to which full consideration will be given.

So much for the review of past policy and our organisation. The results of the recent battle experience in Normandy have been included in the attached report. There are, however, certain aspects of future development, such as the new special 6-pdr. shot, which must be treated with the greatest secrecy, and I feel sure your Committee will appreciate that fact.

I note that your Committee had it in mind to present a further report to the House of Commons. Whether they will think it necessary to do so now in the light of what was said during the Secret Debate and of what is said in the enclosed memorandum is, of course, a matter for them to determine, but if they do decide to publish a Report, in which event I am sure they would weigh their words with a full sense of responsibility, I would ask that any reference that is made to current experience and future developments shall be general in character and in such terms as to avoid giving information which could conceivably be of any value to the enemy.

II.—DRAFT REPLY TO THE MEMORANDUM ON TANK PRODUCTION BY THE SELECT
COMMITTEE ON NATIONAL EXPENDITURE.

I.—INTRODUCTORY.

The Committee, in paragraph 4 of their report, draw attention to the special difficulties with which they have been faced in giving a fair appreciation of the Cromwell tank before it has undergone what the Committee rightly regard as the only real test—the test of battle. In subsequent paragraphs (paragraphs 8 (b) and 10 (iii)) the Committee express certain doubts as to the operational effectiveness of the Churchill. They further, in paragraph 10 (i), draw attention to the armament of the German Panther and Tiger tanks and infer that the armament of British tanks will not prove a match for that of their opponents.

2. Now that British tanks, including both Cromwell and Churchill, together with a British adaptation of the Sherman mounting 17-pdr., have been in action in Normandy and that Churchills have been in action in Italy, there is, for the first time, a firmer foundation of fact upon which to base an appraisal of British tank performance, and it will, no doubt, be reassuring to the Committee

to read the following extracts from reports from General Montgomery and General Leese.

3. About the fighting in Normandy, General Montgomery reports as follows:—

“In the fighting to date we have defeated the Germans in battle; and we have had no difficulty in dealing with German armour, once we had grasped the problem. In this connection British armour has played a notable part.

We have nothing to fear from the Panther and Tiger tanks; they are unreliable mechanically, and the Panther is very vulnerable from the flanks. Our 17-pdr. gun will go right through them. Provided our tactics are good we can defeat them without difficulty.”

Other reports from Normandy indicate that the Cromwell possesses speed, handiness and cross-country ability, which make it superior in these respects to other tanks. The Cromwell is, as the Committee will appreciate, primarily a weapon of offence. The Tiger and Panther are primarily weapons of defence and are being definitely used as such in the present fighting in Normandy.

4. Of the part played by Churchills in the fighting in Italy, General Leese reports as follows:—

“It may interest you to know of the fine performance of the Churchill tanks which supported the Canadian Corps when they attacked and broke through the Adolf Hitler Line last month.

The Churchills stood up to a lot of punishment from heavy anti-tank guns. Several tanks were hard hit without the crews being injured. They got across some amazingly rough ground. Their 6-pdr. guns made good penetration and were quick to load and aim.

So good was the work of this Brigade with their Churchills that the Canadians have as a privilege asked them to bear the Maple Leaf on their tanks.

The tank crews have come through their successful attack on the Adolf Hitler Line with tremendous confidence in the Churchill tank. We shall make good use of every Churchill you send us.”

5. It is perhaps too early to come to a final judgment on matters of relative efficiency of different types in the light of the conditions which are being, and are likely to be, met with in North-West Europe. But, whereas in previous operations it cannot be denied that, with the exception only of the Churchill tank, the most effective tanks and tank weapons available to the Allies have been of American origin, the lead both in armament, ammunition and armour protection has passed to tanks and weapons of British manufacture and design and to conversions designed and carried out in this country, such as the mounting of 17-pdr. in the Sherman tank.

6. The reliability of the Cromwell has been proved and there is no doubt as to its efficiency as a fighting weapon. The Churchill, and to a lesser degree the Cromwell, still require more maintenance than the Sherman. This, however, is to be expected in view of the heavy weight of Churchill and the high performance of Cromwell.

7. No single new or unexpected fact has emerged from the experience of armoured operations in Normandy. In every case tank armaments and armour have acted and reacted exactly as was foreseen, and have accomplished what was known and expected of them. One possible exception to this statement is the new secret 6-pdr. special shot, which, though it has given the penetration expected of it, appears to have had an even greater lethal effect after penetration than was foreseen.

8. No new tank weapon or type of ammunition has been employed by the enemy on this front, whereas we have put into action for the first time in these operations:—

Sherman tanks mounting the 17-pdr. gun.

Churchill tanks carrying 6in. of frontal armour.

The Cromwell tank.

The Crocodile Tank Flame Thrower.

The D.D. Amphibious Sherman tank, and

6-pdr. special shot; and

other special adaptations and devices of lesser importance.

} All strictly secret.

9. Lastly, the lines of future development which General Montgomery advocates substantially coincide with and reinforce the policy we are at this moment pursuing; they also coincide with the views we have received from Italy.

10. The following paragraphs contain a detailed commentary on the Committee's Report.

II.—THE RESULTS ACHIEVED IN 1943.

(A) *General Comment.*

11. The Committee record their general impression that 1943 results, measured in terms of tanks fit for current battle requirements, have fallen far short of expectations, and been wasteful of expenditure.

12. It is true that some of the expectations that existed at the end of 1942 have not been realised in 1943, but the availability of American Sherman tanks in considerable numbers, and the pause in tank warfare since the end of the Tunisian Campaign have given an opportunity of overhauling our tank production policy and placing it on a sounder footing. These two factors removed, for the first time since Dunkirk, the fear of a quantitative deficiency which had previously prevented development of tank design and production on the lines which, but for that fear, would have been followed. The situation in 1943 enabled a drastic reshaping of our tank production policy, and this accounts in large measure for the fact that 1943 output fell substantially short of the estimate made at the end of 1942.

13. As regards expenditure, the Committee claim that tanks cost the Ministry of Supply 18·79 per cent. of their total expenditure on war-stores during 1942–43. The figure actually supplied by the Ministry of Supply and correctly quoted by the Committee in Appendix I to their 14th Report was 17·69 per cent. But this related not to expenditure on tanks, but to orders placed for tanks and all tracked vehicles in the year 1942–43. Expenditure on tanks as such represented 9 per cent. and not 18·79 per cent. of the Ministry's total expenditure in that period.

(B) *Prospect v. Performance.*

14. The main points to be noted are :—

- (a) That the Crusader chassis proved suitable for special operational rôles, for which no other existing chassis was available.
- (b) The General Staff do indeed require Churchills as Infantry tanks and they are now in use in France and Italy. These tanks played a decisive part in the breaking of the Adolf Hitler Line and, as indicated above, we have received favourable reports on them, and also on the Heavy Churchills, from Normandy.
- (c) That the Cromwell would have been used, if it had been required in 1943; but since there was little tank fighting and Shermans were available, opportunity was taken to submit it to prolonged tests and modification in order to bring it up to the present high standard. Units equipped with these tanks are now in action in Normandy, and General Montgomery reports that they are proving reliable and with other British armour are playing a notable part in the battle.

(C) *The Operational Dividend.*

15. On page 5 of the Report the Committee gave a table in four columns purporting to show that the *operational* dividend in gun-tanks was nil in the case of all tanks except Valentines and Churchills and a few Matildas. This by itself is somewhat misleading. If there had been major tank battles since Tunisia, the picture would have been quite different.

16. Moreover, the Committee's conception of "Operational Dividend" takes no account of the need for large numbers of tanks for training, which is itself an important operational requirement. The 1943 Cromwells have been largely used for this purpose and the Centaurs, which, except for their engines, are identical with Cromwells, have been most valuable for training, and have enabled the Meteor-engined Cromwells to be reserved for battle-tanks or more advanced training. It is relevant to note that many hundreds of Shermans have likewise had to be used for training.

17. The Committee also do less than justice to the importance and urgency of the special operational rôles for which Crusaders in particular have been adapted. Vehicles for these purposes could not have been obtained nearly so quickly or economically had they had to be specially designed as the Committee appear to recommend (Report, paragraph 19). Special designing and switching over of production to a new type might, indeed, have taken 2 years or more.

The Major-General, Royal Artillery, 21st Army Group, has reported verbally that the Crusader as a tower for the 17-pdr. has proved a success. Other reports from Normandy indicate that all users speak well of this equipment and that it has been mechanically reliable.

18. With these considerations in mind, the correct heading for the third column of the table should have been "Operationally used as gun-tanks." The table would then be substantially correct, though it would not prove the Committee's contention.

III.—THE FUTURE PROGRAMME.

19. Under this heading the Committee make several comments on armament development which can be more appropriately dealt with below in section III of this Reply devoted to armament questions.

20. On the *Cruiser tank* programme the Committee comment on the tailing off of the Cromwell production after mid-1944. Some tailing off will occur, but there will still be substantial production of Cromwells throughout 1944, and maybe into 1945. The A. 34, which will eventually supersede the Cromwell, should not have the serious teething troubles which the Committee expect, as it is based upon and follows closely the now reliable Cromwell design.

21. The Committee's remarks on the Churchill developments are substantially correct. But their assumption that no Churchills are required with 6-pdr. guns is incorrect. In fact, Churchills with 6-pdrs. have been effective in Italy and in Normandy, and General Montgomery has asked that one-quarter of his Churchill tanks should be equipped with 6-pdr. guns, this being in line with existing General Staff policy. He reports in particular that the 6-pdr., with special H.V. armour-piercing ammunition, is a very good weapon and will penetrate the Panther tank anywhere, except frontally on the sloping plate.

IV.—DEVELOPMENT OF ARMAMENT.

22. Under this heading the Committee comment on the impressions of delay and failure which they sense in the development of a satisfactory tank-gun.

(a) *The 6-pdr. gun.*

23. The Committee claim that, owing to its ineffective H.E. shell, this gun has been considered inadequate as a general tank gun since December 1942, and they ask why there has been so long a delay in replacing it by the 75-mm. gun (Report, paragraph 19). The fact is, however, that the 6-pdr. gun, with its superior A.P. performance as compared with the 75-mm., remains a standard General Staff requirement for an appreciable proportion of tanks (*vide* paragraph 21 above).

(b) *The 77-mm.*

24. The Committee recognise that this gun will give a better A.P. performance than the 75-mm., but state that the gun has not yet been produced and fired and its H.E. ammunition design is still under discussion. This may have been true at the time the Report was written, but both gun and gun mounting had been produced and passed its C.I.A. test some considerable time before the Report was issued; the design of the H.E. projectile, also, is completed and the ammunition will be available when required.

(c) *The 75-mm.*

25. The Committee devote a considerable portion of their Report to the story of this gun and its teething troubles, and they claim (Report, paragraph 13)—

- (i) That there was delay in getting this gun with a serviceable mounting fitted to Cromwells and Churchills.

- (ii) That a design for mounting, which later proved dangerously inadequate, was approved for production.
- (iii) That tanks were issued to field formations with the defective gun mountings and that this had a bad effect on morale, as warnings had to be given.
- (iv) That officers going through the A.F.V. school have had to be instructed on gearing known to be defective.

26. The official General Staff policy on tank armament during 1942 required the tank gun to be a first-class anti-tank weapon and, secondarily, as effective as possible against personnel and lorries. Battle experience at the end of 1942 and evolution of tank tactics caused a change and on the 3rd January, 1943, the General Staff laid down that the main armament of the greater proportion of medium tanks should be an effective H.E. weapon, and, secondarily, as effective as possible against enemy armour. The rest were to have an armour-piercing weapon of high performance.

27. The Ministry of Supply proceeded without delay to develop the 75-mm. gun. It is the case that there were difficulties and disappointments. The new gun began to be issued to troops within 9 months of the decision to adopt it (*i.e.*, in October 1943). However, after its introduction into the Service, weaknesses in the semi-automatic gear became apparent and to overcome these important modifications had to be introduced. To say that the consequent delay could have been avoided by more extensive trials is to argue backwards. Trials were carried out on the normal scale which has proved adequate for other guns and this is one of the cases where weaknesses were revealed in service use which were not shown up in acceptance trials. The necessary modifications were rapidly introduced and all tanks mounting the 75-mm. guns are now completely modified to the approved standard.

28. In paragraphs 30-33 of their Report the Committee endeavour to assess the factors which have contributed to the disappointments that occurred in the case of this gun. The Committee themselves clearly recognise that the matter is one involving complicated technical issues. While not agreeing with all the inferences drawn by the Committee, it is true that mistakes were made and wrong materials used and steps have been taken to ensure that the lesson will be applied in the conduct of future trials, and in production.

29. As regards the Committee's "practical conclusions from the failure" (Report paragraph 34), the following points may be made. The normal tests were carried out. The design was carried out by the Technical Department of D.T.D. with full knowledge of the problems concerned. The trials were carried out under the supervision of C.I.A. and gave results which were considered satisfactory, and these results were confirmed at the trial carried out at Lulworth in the summer. These trials were conducted by a combination of D.T.D. and the Experimental Wing of the War Office Tank Gunnery School. Officers with recent battle experience were present at the Lulworth trials.

30. The Committee also comment on the danger of split responsibility (Report paragraph 35), the D.G. of A.'s responsibility being limited to development and inspection of the gun itself and its ammunition. The line, however, must be drawn somewhere, and it should be noted that the relation of the gun-mounting to the turret and fighting compartment is even closer and more complex than the relation of the gun to the mounting. The addition of the D.G. of A. to the Tank Board will assist the smooth working of the machinery for co-operation.

V.—THE SIGNIFICANT POINTS IN THE RESULTS OF 1943.

31. The Committee pick out as outstanding "faulty appreciations" at the end of 1942:—

- (a) The decision "to put all eggs into one basket" and concentrate on a still unproved type of cruiser tank (the Cromwell).
- (b) The decision to continue to rely for the major part of the programme on an engine (the Liberty) which on past performance was proved inadequate.
- (c) The decision regarding the parent firm for the Cromwell.

32. On these the following comments are made:—

- (a) The decision to press forward with the Cromwell against a background of available Shermans has been fully justified by recent experience in Normandy.
- (b) The Liberty engine had to be used at the outset of 1943 because no other engine of sufficient power was developed and capable of being produced in adequate numbers for the tank programme then contemplated. On the basis of a decision taken in September 1942 the Meteor capacity was expanded with the greatest speed that circumstances allowed, but this expansion could give no yield of complete engines in 1943.
- (c) The Committee have apparently misunderstood the history of the Cromwell parentage. It was the declared intention of the Ministry from an early stage to entrust the parentage of this machine to the Vauxhall firm as soon as their commitments in respect of the Churchill permitted. In pursuance of this policy the Vauxhall firm were associated with development work on the Cromwell from an early date and actually built several prototypes. When, however, it became necessary to continue the production of Churchills and to embark on further development of this type of Infantry tank, it was clear that the Vauxhall firm could no longer undertake the parentage of the totally different Cromwell. Steps were therefore taken as early as possible to bring to an end the arrangements—which had always been regarded as provisional—under which the Birmingham Railway Carriage firm had acted as temporary parents, and to transfer the parentage formally and finally to Leylands.

33. The following are the specific answers to the questions posed by the Committee in paragraph 19:—

(a) Could not the decisions reversing earlier policy (*e.g.*, as regards the Meteor engine programme) have been taken earlier?

(a) No. The decision to develop Meteor capacity independent of aero-engine capacity was taken at the earliest moment at which it could be implemented, *i.e.*, September 1942.

(b) Has it really been necessary, for the sake of avoiding dislocation in employment, to continue the production of obsolete or condemned types of vehicle and engine so long as has been done?

(b) Even assuming that the vehicles referred to were fully obsolete or condemned (which is not true), abrupt termination of programme would have disrupted the production organisation of manufacturers to an extent which would have crippled the further production of tanks in this manufacturing capacity.

(c) When it was decided that certain tanks (Crusader, Cavalier, Centaur) must continue in production even though they would not be accepted as gun-tanks, was the task of preparing all the modifications and appliances which would be necessary for their alternative uses undertaken with sufficient vigour and foresight? We understand, for example, that the production of Centaurs as gun-tanks has been continued much longer than was intended because the fittings and modifications required for using them as A.A. tanks were not ready. Our evidence also suggests some confusion as regards the equipment and uses of O.P. tanks.

(c) Yes. When a decision was taken to discontinue the use of a model as a gun-tank, no avoidable delay in stopping production of such gun-tanks occurred. Production of chassis necessarily continued in advance of the supply of fitments required for special rôles, which fitments frequently involved novel and complex design and production problems.

(d) Lastly, and most important, the question already referred to: why has there been so long a delay in replacing the 6-pdr. with the 75-mm. gun?

(d) This question has been dealt with above (paragraph 15 *et seq.*)

34. The Committee's comments on the future programme for Cromwells and A. 34's in paragraph 20 of the Report are answered in paragraph 10 above.

35. Under the heading of "the inescapable facts" the Committee record the following impressions of the general results of the production story in 1943:—

- (i) That, apart from the Valentine used in Russia and the Churchill in Tunisia, no British tanks during 1943 have been considered worthy of a place in the main battles.

This is answered in paragraphs 14 (b) and 5 *et seq* above.

- (ii) That British tanks issued to British troops have gained a bad reputation both for mechanical reliability and fighting arrangements.

This is a sweeping statement which fails to take into account the situation which this country found itself in after Dunkirk and of the many difficulties that have had to be overcome since then. Recent reports from operational theatres show that the Churchill and Cromwell have proved reliable.

- (iii) That British factory workers have seen very large quantities of completed tanks broken up or parts (finished and half finished) piling up to be taken away as scrap.

This ignores the fact that after Dunkirk tanks had to be produced in numbers suitable at any rate for home defence in a time of desperate emergency. Such tanks fulfilled this purpose and also a useful training rôle, but it is not surprising, and should not be a reflection on the organisation in 1943 that Covenanters and Matildas of 1940-41 now have to be scrapped. The inference from the Committee's statement that it is quite common for British workers to complete tanks and then see them broken up before being used is wrong. No finished tanks have been broken up before they have completed a considerable mileage in training and other uses.

- (iv) That these things have combined to create a most unfortunate psychological atmosphere amongst workers and troops, which deserves the urgent attention of the War Cabinet.

Although such an atmosphere may unquestionably be encouraged by irresponsible public criticism, those who are directly and continuously in touch with the workers on the one hand and the troops on the other are not prepared to subscribe to the views expressed by the Committee. As indicated above, the recent performance of British tanks in battle has provided the best possible reassurance.

VI.—LESSONS FROM SPECIAL CASES.

36. The Committee comment in some detail on the lessons to be learnt from a short preliminary report they have seen about the 3,000-mile reliability trial.

37.—A. The trials are said to have brought to light a few serious design defects, but "a lot of very serious manufacturing faults."

It is admitted that in some cases faulty materials and workmanship have found their way into completed tanks. Every effort has been, and will continue to be, made to eliminate them, and complaints of this sort have been greatly reduced. It is believed that the inspection system which has been built up and reorganised over the past year or more (see paragraph 51) will result in a continued improvement. Isolated cases of faulty workmanship and materials are liable to be exaggerated, and to draw the conclusion that the tank programme as a whole is suffering seriously from such defects would be a gross injustice to the large majority of manufacturers and workpeople employed.

38.—B. Parent firms, although held responsible by the Ministry of Supply for the products of the whole group, have no established authority to control working methods of members of a group.

The principle underlying this comment may be sound, but its practical application is a matter of great difficulty. The principle of supporting the authority of the parent company is a matter to which the Ministry of Supply is devoting constant attention.

39.—C. It is important to use the greatest care in selecting sub-contractors.

This is agreed, but it should be remembered that the rapid expansion of the tank industry took place after the expansion of both naval and aircraft production and at a later stage of the general expansion of munitions production, so

that a number of firms who might have been the most suitable for many important tank components were not available.

40.—D. There is a shortage of qualified staff both for inspection by the I.F.V. and inspection by manufacturers themselves, and this can only be countered by (a) transferring selected R.E.M.E. personnel to the I.F.V. and (b) taking a certain number of trained personnel in the factories off production, if necessary facing a loss in quantity to secure a better guarantee of quality.

The shortage of trained personnel is admitted but it is an *overall* shortage (see paragraph 51).

VII.—CONCLUSIONS AND RECOMMENDATIONS.

41. Comments on the "Main Conclusions," and the "Recommendations," of the Report (paragraph 37 to the end) may conveniently be taken together.

A. *The Immediate Emergency.*

42. The Committee comment that it is of supreme importance that when Cromwell tanks are first tested in battle they should not fail in reliability and that requirements in respect of these first issues of Cromwells must have superiority. Any failure of these tanks would, in the Committee's view, finally shake the confidence of British troops in the British cruiser tank.

This is accepted in full and every effort has been made to ensure that these tanks, when issued to operational troops, are in as perfect a condition as can be achieved, and it is evident from recent reports that a high degree of success has been obtained.

B. *Organisation and Responsibility.*

43. The Committee set as their ideal objective the reunion under the War Office of all responsibility for obtaining production of technical instruments of war, such as tanks.

The Committee do not suggest in what way this transfer back to War Office would in fact meet the ills they describe. At this stage of the war retransfer of research design and production functions to the War Office would be little more than a nominal change since the same staff would need to be employed in more or less the same places. Most of the problems of responsibility and liaison to which the Committee draw attention would remain in what would inevitably be a vast production organisation under the War Office. In any case, now is not the time to undertake such a complete reversal of the policy followed since 1939.

44. Pending the full implementation of the change suggested in the preceding paragraph the Committee recommend that everything possible should be done to create a close partnership between War Office, Ministry of Supply and manufacturers, the dominating lead being taken by the War Office.

Such a partnership already exists and the War Office does in a real sense already occupy the dominant position since it is the customer and initiates the requirements. Full contacts are provided by the Tank Board, and at this level, as well as at all lower levels, a real integration of effort between the two Departments concerned has been and is increasingly being achieved.

45. The Committee claim that the Tank Board is becoming a less effective executive instrument than in the past. That is not so. The Board's executive authority is subject only to the agreement of the two Ministers concerned and of the War Cabinet where necessary. The Board's day-to-day decisions operate without let or hindrance. The executive functions of the Board are exercised primarily in the Ministry of Supply's province, and therefore the Committee's view that the Chairman of the Board should be a War Office representative may be questioned. It is the considered view of Departments that the realistic approach is to appoint the best Chairman available irrespective of the Department to which he belongs. It may be added that the War Office themselves do not desire a change in the present constitution of the Tank Board.

46. The Committee's view that the Tank Board should be as small in number as possible is accepted, as is their recommendation that the D.G. of A. should be a member of the Tank Board. Their recommendation that C.A.F.V. or D.G.A.F.V. should be given full responsibility in carrying out in terms of production the Tank Board's decisions is a reflection of present practice.

47. The Committee recommend that representatives of select parent firms should normally attend all meetings of the Board but need not be members. Such representatives have several times been invited to Board meetings to deal with particular problems, but it is not thought desirable or necessary that they should attend all meetings.

48. With regard to the recommendation that there should always be adequate representation of recent tank-fighting experience, it should be noted that the War Office representation on the Tank Board does at present include an officer with outstanding experience of such a kind.

49. Within the War Office the Committee recommend that there should be a closer unity of responsibilities and that officers with recent operational experience should be kept in constant contact with all stages. The unity of responsibility to which the Committee refer is in fact attained under D.C.I.G.S. for all things which are the province of the War Office.

With regard to the comprehensive Tank Centre which the Committee recommend, the arrangements between War Office and Ministry of Supply for carrying out tests and trials are working smoothly, and, with the exception of facilities for gunnery trials, the establishment at Chobham fulfils the requirement. An entirely new Centre, with facilities for all types of trials, embracing those undertaken at Chobham, Shoeburyness and Lulworth, would not be justified at this stage of the war.

50. The Committee consider (Report paragraph 47) that the present division of responsibility involves the danger that the manufacturers may not feel responsible for results, and they contrast this position with that in the aircraft industry where the reputation of the producer is closely knit with the performance of the plane. It is to counteract this tendency that the recommendation that members of three firms—Vauxhall, Leyland and Vickers—should normally attend meetings of the Tank Board is made (see paragraph 37 above). The Committee also recommend that immediately a new type of tank is decided upon, responsibility for parentage should be allocated to an organisation of proved efficiency with an adequate team of engineers and that thereafter no work on the designs and development should be done by Departments unless in co-operation with the parent firm.

It is accepted Departmental policy to entrust a new type of tank to a single manufacturing organisation of proved efficiency and thereafter to place the fullest possible responsibility for design on the selected parent firm. Only one firm, however, has the necessary specialist resources to handle many of the technical design problems relating to the fighting qualities of tanks and firms must therefore continue to rely on the War Office and Ministry of Supply for a great deal of help. It is in general not the practice of D.T.D. to work independently, but rather to assist the design staff of the parent firm and to work in close consultation with them. The Committee's observations in fact do less than justice to the help given by D.T.D. to parent design firms on the fighting side of tanks.

C.—Workmanship, materials and inspection.

51. The Committee recommend that every possible step towards improvement, where necessary, should be taken; that the inspecting staff of I.F.V. should be overhauled drastically; and that it would be justifiable to face some sacrifice in quantity of tanks produced in order to attain a higher quality and therefore if necessary recruitment for manufacturers' inspection staffs should be from the production lines (this applies also to sub-contractors.)

The need for strengthening inspection staffs has been fully recognised. Industry and the Armed Forces have been drawn on for recruitment of inspection personnel to the fullest extent possible and the numbers of technical staff employed on tank inspection work were doubled between November 1942 and March 1944. Man-power limitations are however very severe and the withdrawal of any substantial number of men from production lines or R.E.M.E. is by no means so simple as the Committee would suggest. Departmental policy, as developed in 1943, has been to emphasise quality rather than quantity in tank production, a change in emphasis then for the first time made fully possible owing to the circumstances outlined in paragraph 2 above.

D.—*Lack of urgency: priority for the tank programme.*

52. The Committee record (Report, paragraph 50) their general impression that owing to the availability of Shermans there has been a lack of a sense of urgency and drive behind the whole British tank programme. That there has been any such lack is denied. The Committee proceed to recommend that "there should be no doubt about adequate priority for everything that is involved in the agreed tank programme." Up to the autumn of 1943 the tank programme undoubtedly had a lower priority than aircraft, but since that date arrangements have been made in collaboration with the Ministry of Production for all essential parts of the tank programme to be given equal first priority.

E.—*Links with fighting experience.*

54. The Committee consider that the procedure for introducing minor modifications proved necessary by fighting experience should be improved. The Ministry of Supply, with War Office assistance, maintain in all theatres of war extensive military technical services which act as a direct and efficient link between the troops in the battle lines and the design and production organisations. Further methods of strengthening such links are continually being studied. Officers with recent operational experience are kept in close touch with all stages of development.

F.—*Result of failure to implement recommendations.*

55. The Committee finally conclude that unless determined steps are now taken to improve the organisation for Tank development and production, money and war resources will continue to be wasted, and, what is worse, there is a serious danger that the country will at the end of the war have no properly functioning organisation for handling this extremely important branch of mechanical warfare.

It is agreed that it would be a national disaster if the country were to fail during the war to build up a first-class organisation for producing British tanks. With the growth of experience in industry and in Government establishments this objective is being progressively achieved and the Committee need have no fear that every effort is not being exerted towards that end.

III.—A SUMMARY OF REPORTS RECEIVED ON THE PERFORMANCE OF BRITISH TANKS.

The principal points brought out by General Montgomery's Memorandum, the War Office comments thereon, and the latest operational reports are as follows:—

Guns.

The 17-pdr. and the 6-pdr. with Sabot ammunition are extremely effective.

It is quite clear that the fitting of the 17-pdr. to the Sherman tank was of the highest operational value and we are pressing on with further conversions.

Although General Montgomery draws attention to the weakness of the 75-mm. as an armour-piercing weapon, its H.E. shell is good and as an all-purpose weapon the gun is still popular; further, it proved of great value in the assault phase, both in normal tanks and in D.D. Sherman and Flail tanks.

It must, however, owing to its poor penetrative power, be considered as out-moded, and its place must be taken as and when possible by the 77-mm. and 17-pdr.

The 6-pdr. Sabot has been a great success, and Churchill tanks with this gun and ammunition are being provided in the ratio which General Montgomery now asks for, namely, one per group of three tanks. Sabot ammunition is now coming out of production for the 17-pdr., and it will also be available for the 77-mm. (which takes the same shell and which is the gun of the improved version of the Cromwell (Comet)) when tanks with this gun come into use.

Armour.

General Montgomery would like to see our armour increased and more use made of sloping plates. The War Office, however, point out that the heavy Churchill has very considerably better armour than Tiger, Comet has frontal armour of approximately the same thickness as Tiger, and in the newly-designed Cruiser tank, A.41, a sloping frontal plate superior to that of Panther is used.

Reliability.

The Sherman is still the most reliable tank if low maintenance is taken as one of the criteria of reliability. In actual operations the reliability of the Cromwell has been proved, but it is nevertheless true to say that the Churchill, and to a lesser degree the Cromwell, still require more maintenance than the Sherman. This is to be expected in view of the heavy weight of the Churchill and the high performance of the Cromwell. Tiger and Panther are relatively unreliable.

General Montgomery has a certain amount to say about optical instruments. His points of criticism have, however, already been largely met, and binoculars (*e.g.* the No. 5 already issued) and telescopes (*e.g.* the new 3-power telescope) now in production should improve matters very much.

As is stated in the note to the Select Committee, it is clear from General Montgomery's report that the lead—both in armament, ammunition and armour protection—has passed to tanks and weapons of British manufacture and design, and that the development policy which we are now pursuing is in accord with the lessons to be learnt from the most recent battle experience.

Printed for the War Cabinet. May 1944.

The circulation of this paper has been strictly limited. It is issued
for the personal use of *Lord President (dup)*

TOP SECRET.

Copy No. 4

W.P. (44) 262.

23rd May, 1944.

WAR CABINET.

SELECT COMMITTEE ON NATIONAL EXPENDITURE: REPORT ON TANK PRODUCTION.

NOTE BY THE SECRETARY OF THE WAR CABINET.

BY direction of the Prime Minister I circulate herewith for the consideration of the War Cabinet—

- I. A Report of the Select Committee on National Expenditure on Tank Production, dated the 9th March, 1944.
- II. A Memorandum by the Minister of Production dated the 20th May, 1944, submitting to the Prime Minister the observations of the Secretary of State for War, Minister of Supply and himself on the Select Committee's Report, with enclosures.
- III. A letter from Sir John Wardlaw Milne to the Prime Minister, dated the 10th May, 1944, asking for early consideration of the Report.
- IV. An interim reply which the Prime Minister proposes to send to Sir John Wardlaw Milne.

(Signed) E. E. BRIDGES.

Offices of the War Cabinet, S.W. 1.
23rd May, 1944.

4
have not been given full information on the programme that lies ahead, so that we are without all the data for judging how the present organisation is working.

5. In these circumstances we have decided that our right course is in the first place to submit a Secret Memorandum to the War Cabinet stating our impressions and recommendations. We had contemplated that we should then, in the light of the reply received, decide in what sense we should report to the House of Commons. In the course of the final completion of this Memorandum, however, there occurred the discussion of the 2nd March in the House leading to the prospect of an early debate on tanks in secret session. In view of this, and of what has been stated in the 18th Report of 1941-42, we must take into account our responsibilities in regard to reporting to the House at an early date.

(3) EVIDENCE TAKEN.

6. On the 28th September, 1943, we asked for certain factual information from the Ministry of Supply and later, in November, 1943, further inquiries were submitted to the War Office. In response to these approaches a memorandum prepared jointly by the War Office and the Ministry of Supply was given to us late in December 1943. This document, to which we refer hereafter as the "War Office Memorandum," has been supplemented at various times by further information prepared for the most part jointly by the two Departments.

Apart from this body of written official evidence we have examined a number of witnesses orally: on the Army side, representatives of the General Staff, the Royal Armoured Corps and officers from the Gunnery and Experimental Wings at Lulworth; and on the Ministry of Supply side, departmental representatives on the Tank Board, officers of the development section under D.T.D. at Lulworth, and the Director-General of Artillery. In addition, we have had a substantial body of evidence from manufacturers engaged in both assembly work and engine production.

The Results Achieved in 1943.

(1) THE GENERAL PICTURE.

7. On our review of the position, it is impossible to avoid the general impression that, measured in terms of production of tanks fit for current battle requirements, the British manufacturing effort of 1943 has fallen far short of realising expectations or being fully effective, and has involved what appears to be a wasteful use of national resources. We cannot, from our evidence, state the exact significance of this in terms of cash expenditure; but that the amounts involved are very large is shown by a statement, furnished by the Ministry of Supply for another inquiry, according to which expenditure on tanks represented 18.79 per cent. of their total expenditure on War Stores for 1942-43.

The picture, as it has impressed itself on us, is drawn broadly in two ways in the two succeeding paragraphs:—

(a) "Prospect," as forecast in 1942, compared with "Performance" in 1943.

8. In the first place we have compared "prospect" with "performance" by setting the achievement up to the end of 1943 side by side with our impression of the prospect as it was presented to us in the autumn of 1942.

(NOTE.—In the comparisons set out below—

(a) We have, for the sake of simplification, left out any reference to the Valentine production. Full credit should, of course, be given for the continuity of this part of the programme.

(b) We have, on the "prospect" side, set out the general impressions which we gained, directly and indirectly, from a wide body of evidence.)

5
Main points in the "Prospect" as presented in the autumn of 1942.

(a) That the Crusader had proved unreliable and was to go out of production.

(b) That the Infantry Mk. IV (Churchill), though justified for its original home defence purpose, did not justify continuance for overseas fighting and was to go out of production at the end of the current contract (early summer, 1943) and that the whole Vauxhall Group should then go over to cruiser tanks.

(c) That the Cromwell, with a Meteor engine and carrying a 6-pdr. gun, was going to be the best tank in the world, and an important factor already in 1943 fighting.

(d) That the Centaur, with Liberty engine, was going to be a very close second-best to the Cromwell (in fact identical except at the highest speeds).

(e) That the Centaur was to be adopted because, owing to the demands of the M.A.P. Merlin engine programme, a sufficient production of Meteor engines for the total cruiser programme could not be organised.

(f) That the whole British effort would be concentrated on the Cromwell type of cruiser tank, and that the production of an infantry tank would cease to be part of the British programme.

Actual "performance" in 1943.

(a) Crusaders still represented 26 per cent. of the total tanks produced in 1943.

(b) The Churchill has, according to the Memorandum submitted by the War Office, "established itself as a reliable and efficient weapon, having stood the test of battle experience in Tunisia and won the confidence of the troops." (But N.B.—It has been allowed to drop out of battle since Tunisia, apparently owing to the armament being judged insufficient.)

(c) The Cromwell had, up to the end of 1943, not proved in *quality* to be a vehicle of sufficiently reliable performance to be used in battle. Its production in *quantity* fell far short of the programme. As a result it was considered necessary to change the "parentage" for Cromwell production in May 1943. Even if as armoured vehicles Cromwells had been adequately reliable, they would not have been sent abroad because, by the time they came into production, the General Staff had come to regard a cruiser tank equipped with a 6-pdr. gun as inadequate.

(d) The Centaur, with its Liberty engine, proved so unreliable when handled by units at home that, as a gun-tank, it has been condemned. The Liberty engine is to go out of production, but, in order not to break up manufacturers' organisations, production will have to continue long after condemnation as a gun-tank engine.

(e) It has been found possible during 1943 to organise the production of Meteor engines on a scale which is claimed to be adequate for the whole cruiser tank programme.

(f) The General Staff have accepted the policy that an infantry tank of the Churchill type is an indispensable part of the British programme.

(b) Resources invested and "Operational Dividend" in 1943.

9. An alternative method for getting a broad impression of the factual results is to compare the resources invested with the "operational dividend" realised. We have accordingly enquired what proportion of the tanks produced during 1943 proved to be of value for the purposes for which they were planned, viz., as gun-tanks to be used by armoured formations. The results are indicated

in the following table compiled from information furnished by the Ministry of Supply:—

Type.	Percentage of Total Number of Tanks produced during 1943.	Operationally adequate as Gun-tanks.	Actual Utilisation.
Covenanter ...	0.5	Nil	Obsolete.
Crusader ...	26	Nil	Two-thirds being converted as gun-towers, A.A. tanks, &c. One-third for training.
Cavalier ...	5 1/2	Nil	Half stated by Ministry of Supply to be destined as O.P. tanks. The War Office evidence throws doubt on their value for this purpose. Half for training.
Centaur ...	17	Nil	Two-thirds for training, one-twelfth operationally with 95 mm. One-quarter intended probably for training.
Cromwell ...	7.5	Nil	Ministry of Supply say for operational units or training. But War Office evidence is that up to 1st January, 1944, no production models were accepted as adequate for battle overseas.
Matilda ...	2	A small number for Far East.	Mainly for mine-sweeping.
Valentine ...	24	All operational; mainly for Russia.	
Churchill ...	18	All operational; but N.B. They have not been used in battle since Tunisia.	

(c) *The Development of the Programme ahead.*

10. Paragraphs 8 and 9 have dealt with actual results. But the achievement of 1943 cannot be fairly judged without taking into account how the programme which lies ahead has been settled and how it now stands. Here we are in an unavoidable difficulty, since we have been precluded from enquiring into details of projected developments. We have, however, in the War Office Memorandum, been given a general indication of present policy, and this has been random, been given a general indication of present policy, and this has been supplemented in certain respects by oral evidence. In order, therefore, to make clear the understanding of the position on which our conclusions and recommendations are based, we set out shortly below such impressions as we have been able to form.

(i) *Armament.*

We understand that the 6-pr., owing to its ineffective H.E. shell, has, since December 1942, been considered inadequate as a general form of tank-gun, but that a small proportion, to fire a special type of A.P. ammunition, may still be required to supplement the 75-mm. gun-tanks; that the 75-mm. M.V. (Medium Velocity) gun is regarded as a reasonably adequate dual-purpose weapon with a fairly good H.E. shell and with an A.P. performance equal to the 6-pr. when both are firing normal A.P.C.B.C. shot; that the "77-mm." will be worth having as giving a better A.P. performance than the 75-mm., though its exact A.P. muzzle velocity and the content of its H.E. shell are still matters of uncertainty; and, finally, that the 17-pr. is the only British gun about which we have been told which, for tank *c.* tank purposes, can be regarded as being in the same class with the German 75-mm. gun in the Panther (Pz Kw V) or the 88-mm. in the Tiger (Pz Kw VI). These impressions have a bearing on our judgment of the present position.

(ii) *Cruiser tank programme.*

The Cromwell (as now coming off the production line with the modifications decided upon after the recent driving test)* is considered for the first time to have got through its teething troubles and to be mechanically reliable. But the Cromwell, even if it has thus attained mechanical reliability, is apparently to have a limited production life. As from the middle of 1944 it is to be tailed off and replaced by a larger tank (A. 34) of the Cromwell type, taking the 77-mm. gun. The A. 34 involves redesigning 60 per cent. of the Cromwell parts. It must, therefore, be regarded as more than a modification, and as involving a factor of uncertainty in that it is likely to have to go through its own teething troubles before it will be accepted as a vehicle reliable for battle. The position as regards armament is even more uncertain. The 77-mm. gun has not yet been produced and fired. The design for its H.E. ammunition is still under discussion. Even if it proves to be a good weapon, it will remain for tank *c.* tank purposes definitely less powerful than the best German tank armament.

(iii) *Infantry tank programme.*

The production of the Churchill with developments is to continue as an important element in the British programme. As from March 1944, the heavier Churchill, Marks VII and VIII, will be in production equipped with the 75-mm. M.V. gun or the 95-mm. gun-howitzer. But, since the standard Churchill has hitherto continued in production with the 6-pr., emergency retrospective modifications will be necessary if those already produced, including those with the troops overseas are to have what the General Staff now consider adequate armament.

(iv) *Other projects, S.P. mountings, &c.*

We have not been permitted to inquire into the very varied range of projects in hand outside the main lines of cruiser and infantry tanks or into the long-range programme for these two types. We have been informed, however, that "projects for the mounting of still larger guns in tanks both of the Cromwell and Churchill series are in hand and have reached varying stages of development."

(2) *SPECIAL ILLUSTRATIVE CASES.*

11. Paragraphs 8, 9 and 10 give the broad picture as it has impressed us. In order to make a closer check of current achievement we have taken evidence from manufacturers, and also examined, in some detail, two recent experiences, viz., the results brought to light in the recent 3,000-miles driving trials, and the story of the 75-mm M.V. gun. Both cases illustrate important points.

(a) *The recent 3,000-Mile Driving Trials.*

12. The points brought to light in the recent driving test indicate that, while the general design of the Cromwell is now considered likely to achieve mechanical reliability, there is still a real risk of failure owing to defects in materials and workmanship. The faults revealed in the test show the need for more rigid qualitative control of materials and for better systems of inspection and works administration, not only in the main assembly firms, but among sub-contractors and manufacturers of every kind of part or component. These matters, which indicate that there is still serious need for improvements in organisation, are more fully examined in a later passage. (See below paragraphs 22 to 29.)

(b) *The Story of the 75-mm. Medium Velocity Gun.*

13. Our investigations of what has occurred in the case of the 75-mm. gun has brought to light several points which are most disturbing. We have been chiefly impressed by the following matters:—

- (a) The delay which has occurred in getting this gun with a serviceable mounting fitted into Cromwell and Churchill tanks;
- (b) The fact that a design for a mounting, which has since proved dangerously inadequate, was approved for production;
- (c) The fact that tanks were issued to field formations with these defective gun-mountings, with the result that it has been necessary to issue

* We understand that the experience in the 3,000-mile trial led to decisions to introduce a number of important modifications which meant holding up tanks coming off the line; but that these modifications have, since the middle of February, been incorporated in production.

- urgent warning notices to the formations concerned—a most unfortunate result in view of the lack of confidence already prevailing in regard to British tanks;
- (d) The fact that officers going through the A.F.V. School have now for several months had to receive instruction on gearing which they knew to be defective, and which they knew would have to be replaced by better gearing in the tanks to be issued for operations.

14. The reasons for what has happened and the defects in organisation which they appear to indicate are more fully dealt with in later paragraphs (30-36). The outstanding point relevant to this part of our memorandum is the delay. In the War Office Memorandum it is stated that the possibility of introducing the 75-mm. M.V. gun as a dual purpose weapon in place of the 6-pr. gun "continuously under review" in 1942; that "in December 1942, as a result of Middle East experience, the General Staff asked that this gun should be adopted as soon as practicable as the main armament of the majority of British Tanks"; and that "on the same date the General Staff were informed by the Ministry of Supply that an outline design had been prepared of the 75-mm. gun to fit into the 6-pr. mounting in British Tanks." Yet this requirement, though shown by fighting experience to be urgent, *though involving none of the complications of producing a new type of ammunition*, and though formulated and accepted in December 1942, had, up till February 1944, remained unsatisfied in terms of serviceable production. Whether reliable mountings will, even now, be produced on a large scale still remains to be proved in practice, but the extremely unfortunate results of the 14 months' delay which has already occurred cannot be escaped. That this delay has not had more operational significance is because no British cruiser tanks, accepted as vehicles fit for battle, were produced during 1943—itsself a most unfortunate result. But the Churchill tanks have, all this time, been available as battle-worthy vehicles, and it appears to us both inexplicable and regrettable that these should have been continued in production throughout 1943 with no better armament than the 6-pr.

The Significant Points in the Results of 1943.

(a) Mitigating Considerations.

15. It is from the broad picture as given in paragraphs 8 to 10, supplemented by our detailed examination of the matters covered by paragraphs 12 to 14, that we have formed our views on the situation. In judging the present organisation we wish to give full weight to all the mitigating considerations that have been put before us. Of these the following seem the most important:—

- Owing to the lag in converting plans into production, the results of 1943 do not necessarily afford a basis for criticising the organisation as it has existed since we last reported, *i.e.*, since the changes made in the autumn of 1942.
- Account must be taken of the handicap under which the British tank production has struggled from the beginning of the war, resulting from the failure to continue on an adequate scale the organisation for tank design which had been built up in the last war.
- British designers have had to cope with special problems such as the limitations imposed by railway transport requirements and the low silhouette demanded by the General Staff.
- Difficulties have been caused by the dispersal of British manufacturing units. (This point is relevant when comparisons are made with the American organisation, which has been able to take advantage of the immense scale and concentration in one convenient centre of the American motor industry.)

(b) The Inescapable Facts.

16. These considerations cannot all be accepted without qualification, and they provide in the main explanations of, rather than justifications for, past shortcomings. (For example, it appears to us that if there had been a more clear and determined purpose, the restrictions referred to under (c) would not have been acquiesced in for so long.) But, whatever their significance, the main facts remain that, apart from the Valentine in Russia and the limited use of the

Churchill in Tunisia, no British* tanks during 1943 have been considered worthy of a place in the main battles; that British tanks issued to British troops have gained a bad reputation both for mechanical reliability and fighting arrangements; that British factory workers have seen very large quantities of completed tanks broken up, or parts (finished and half-finished) piling up to be taken away as scrap; and that these things have combined to create a psychological atmosphere about British tanks among all concerned with handling them which must have unfortunate effects and which in our view deserves the urgent attention of the War Cabinet. The past record in fact puts the onus of proof very heavily on those who claim that all is now well with the organisation for tank production.

(1) OUTSTANDING POINTS IN THE GENERAL PICTURE.

17. From the broad survey (paragraphs 8 to 10) certain points seem to us to stand out for special comment.

18. The contrast between "Prospect" and "Performance" (paragraph 8) seems to indicate that wrong appreciations were made at the end of 1942, and this inevitably affects our judgment of the expectations that are now put forward for 1944 and onwards. The point which we find most disquieting is that it should have been seriously contemplated at the end of 1942 that practically all "the eggs" as regards future tank production should be put into the "one basket" of a type of cruiser tank which was still unproved as a mechanical construction, and which was to rely for the major part of the programme on an engine which, on past performance, could only be regarded as inadequate and which has since proved to be so.

19. The disappointing nature of the "dividend" for 1943 (paragraph 9) tells its own story. The alternative purposes recorded in column 4 of the table in that paragraph are doubtless of value, and other uses may be found of which we have not been informed; but it was not for these purposes that the programme was originally planned, and we cannot believe that these could not have been attained far more economically if they had been the original objective. We recognise, of course, that several of the unsatisfactory features in the "dividend" resulted from decisions which were taken before the changes in organisation, and which have since been reversed. Judging by these reversals, we conclude that the main causes of trouble were, first, the reliance on the Liberty engine, and, secondly, the original selection of the "parent" firm for the Cromwell group. Due credit should be given to those filling the new appointments for facing up to these matters, but there still remain important questions, some of which we set out below:—

- Could not the decisions reversing earlier policy (*e.g.*, as regards the Meteor engine programme) have been taken earlier?
- Has it really been necessary, for the sake of avoiding dislocation in employment, to continue the production of obsolete or condemned types of vehicle and engine so long as has been done?
- When it was decided that certain tanks (Crusader, Cavalier, Centaur) must continue in production even though they would not be accepted as gun-tanks, was the task of preparing all the modifications and appliances which would be necessary for their alternative uses undertaken with sufficient vigour and foresight? We understand, for example, that the production of Centaurs as gun-tanks has been continued much longer than was intended because the fittings and modifications required for using them as A.A. tanks were not ready. Our evidence also suggests some confusion as regards the equipment and uses of O.P. tanks.
- Lastly, and most important, the question already referred to: why has there been so long a delay in replacing the 6-pr. with the 75-mm. gun?

20. When we turn to our impressions on the present programme (paragraph 10), our comments, owing to our lack of full information, can, of course, be

* We fully appreciate that the supply of American tanks may be sufficient to meet the requirements of British troops. But we cannot regard this as affording ground for not considering the British production programme on its merits, and on the assumption that these tanks are urgently required. Otherwise a substantial portion of British resources must be regarded as having been employed without justification.

no more than tentative. We confine ourselves, therefore, to saying that we find it disquieting (a) that the Cromwell, even if it proves now to have attained mechanical reliability, is apparently under sentence of supersession after a few months of production life, (b) that the position as regards the A. 34 should be affected by so many uncertainties, and (c) that there should be no evidence of production from projects on which we had evidence in our visits to factories in the summer of 1942.

(2) LESSONS FROM THE SPECIAL CASES EXAMINED.

21. It has seemed to us important to examine in some detail the special cases referred to in paragraphs 12 to 14 since these not only illustrate the working of the organisation, but also throw light on what is involved in the charge of faulty workmanship which has figured somewhat prominently in our evidence from the General Staff.

(a) *The 3,000-mile Reliability Trial.*

22. We have seen only a short preliminary report from the Fighting Vehicle Proving Establishment on this trial. From this it appears that the results brought out the following main points in the comparison between the Cromwell and the Sherman. The Cromwell has a substantially better driving performance than the Sherman (20 per cent. faster across country, 60 per cent. faster on the road). The Sherman up to 2,000 miles is more reliable (though this result may have been affected by the Sherman being driven at a lower speed). The Cromwell has a longer life (both engine and suspension).

(i) *The significance of "faulty workmanship."*

23. The report also states that the trials brought to light comparatively few serious design defects but "a lot of very serious manufacturing faults in English serious design defects but "a lot of very serious manufacturing faults in English tanks." Further investigation seems to show that the expression "serious manufacturing faults" is somewhat loosely used. Illustrations given of these faults were (a) faulty radiators; (b) wrong fluid in the Lockheed system; (c) badly assembled gear boxes; (d) modifications not fitted (e.g., final drive bolts); (e) fan belts. Of this list it is worth noting that, according to our evidence, only (d)—the failure to introduce the modifications of strengthened final drive bolts—represented a straight fault in manufacture by the main assembly firms. The radiators, the Lockheed units, gear boxes and fan belts, all represented bought-out parts. Further, in these cases, "faulty manufacture" was only partially the cause of trouble. The radiators, for example, we understand were made by sub-contractors to a design settled at the Belper establishment of the Ministry of Supply, and the assembly firm claims that it was a bad design and that their own radiator as made for the "Centaur" proved adequate. The failure in the fan belts was essentially due to faulty material (bad rubber and canvas). Faulty material (faulty synthetic rubber pistons) is alleged also as one of the causes of the Lockheed system failures. In other cases faulty material and workmanship both played a part (e.g., tab-washers to lock the lock-nut in the gear-box made of faulty material and knocked on by a fitter in such a way as to damage the washer). This analysis brings to light a number of points.

(ii) *The authority of parent firms.*

24. The case of the final drive bolts illustrates a matter of considerable importance. The introduction of modifications in the assembly line at the right time depends on having an efficient works system. Even if a parent firm itself has a first-class system of administration and inspection, faults may occur in member firms of a group, and apparently the parent firm, although held responsible by the Ministry of Supply for the products of the whole group, has no established authority to control the working methods of its members. It appears to us that only a firm of proved first-class qualifications should be selected as a parent firm, and that such a firm when selected should be strengthened by official backing. It is, in fact, an essential part of our recommendations that the two or three firms which after four and a half years of war have emerged as worthy for selection as parent firms, should be treated as an integral part of the official organisation with a real share in the responsibility.

(iii) *The importance of careful selection of subsidiary manufacturers.*

25. Another point which emerges is the importance of great care in the selection of firms as sub-contractors or makers of any parts or components required for tanks. The reliability of a tank depends on far more than the work done by the main assembly firms. Apparent carelessness in this matter is brought out in a later paragraph.

(iv) *Faulty material.*

26. Since faulty material has been an appreciable factor, we must emphasise the urgency of ensuring that nothing but the best quality of material is issued for vital parts in tanks or their armament. Fan belts have apparently been a common source of trouble. In the case of such vital accessories as these (or the semi-automatic cam referred to in a later paragraph) the quantity of materials required in relation to total war production is negligible. Selected qualities of rubber, canvas or other materials should be made available for such vital parts.

(v) *The importance of inspection.*

27. Lastly, this case and many others which have come before us illustrate the vital importance of working up standards of inspection. This has to be considered under the two heads of Government inspection by the I.F.V. and inspection by manufacturers.

(vi) *Inspection by the I.F.V.*

28. We understand that the great difficulty has been to get rightly qualified personnel, and that, in default of this, it has been necessary to rely on employing greater numbers and on the rule-of-thumb method of inspecting according to a list. We are informed that there has been a considerable improvement in the I.F.V. work over the last 12 months, and that the need for further improvement is fully recognised.

It seems obvious that every possible opportunity should be taken for bringing in highly qualified experts, and for training those that are not. We suggest that it might be valuable to transfer selected R.E.M.E personnel to I.F.V.

(vii) *Inspection by manufacturers.*

29. There are three main heads for consideration:—

- (a) The system of inspection by manufacturers within their own works (either by the main assembly firms or by manufacturers of components).
- (b) Inspection by the parent firm of the work done by other members of their group.
- (c) Inspection by the main assembly firms of parts or sub-assemblies made by other firms.

Here again the essential difficulty in all three cases is shortage of highly qualified personnel resulting from the great expansion of work for most of the principal manufacturers. It seems clear that, if manufacturers' inspection could be made more effective by taking a certain number of men off production, it would be worth while to face some loss in quantity for the sake of securing a better guarantee as to quality.

(b) *The Case of the 75-mm. Gun.*

30. We have already mentioned (paragraph 13) the main disturbing points brought to light in this case, of which the most important from a practical point of view has been the delay in getting British tanks equipped with armament which, in the view of the General Staff, was essential. Various factors appear to have contributed to this delay.

(i) *Delay in settling design of mounting.*

31. We have been astonished to learn in evidence that although the requirement was formulated as urgent and accepted as practicable in December 1942, it was not until the 3rd July, 1943, that the responsible officer under C.A.F.V. agreed with D.T.D. that the standard 6-pr. mounting would take the 75-mm subject to defined modifications (a special S.A. cam, and a specially strengthened deflector bracket); and, further, that it was not until the 10th July that the

requirements for the elevating gear were categorically stipulated to the Ministry of Supply by the General Staff (*i.e.*, the requirement for a geared elevation with a definite ratio and for equipment to enable indirect firing to be carried out). We find it difficult to understand why so many months were allowed to elapse without such points being settled, or why the General Staff did not press the matter more urgently. It appears to us that several months were wasted.

32. After this initial delay, matters seem to have been handled expeditiously, since we have been told that tanks equipped with 75-mm. guns began to be issued to formations in this country in October.* Unfortunately, however, this did not mean getting serviceable weapons into the hands of the troops, since the mountings as produced proved to be seriously faulty when fired. There has been substantial further delay in overcoming these faults. On the evidence that we have obtained hitherto, the position is somewhat confusing, and it is difficult to unravel the precise course of events or to understand how it came about that those responsible for designing the mounting did not anticipate the strains to which it would be put when firing American ammunition in service conditions.

(ii) *Evidence on tests and trials.*

33. We may record the following statements from our evidence:—

- (a) That the trials on which reliance seems chiefly to have been placed were—
 - (i) A "user's" trial at Lulworth in March 1943 by the Experimental Officer to D.R.A.C. working with the Officer in Charge of the D.T.D.'s Development Wing. (This was a trial with 100 rounds. The ammunition in this case was hand-picked and about 30 per cent. of the rounds were rejected. It was carried out with a 75-mm. gun in a Valentine tank, on a mild steel fabricated mounting. The results were entirely satisfactory.)
 - (ii) A technical trial by C.I.A. with 200 rounds American ammunition. As in the case of (i), the ammunition was hand-picked, 60 rounds out of the 200 being rejected—and the results were satisfactory.
- (b) That it was on the results of the C.I.A.'s trial that the mounting went into production.
- (c) That the tests referred to under (a) did not show up the weakness in the mounting because the ammunition was hand-picked, whereas the ordinary run of American ammunition may put a much greater strain on the mounting, since it includes rounds which, while not so inaccurate as to fail to go into the breech, are very hard to extract. (This explanation, however, was not accepted as proved by other witnesses—who alleged that it is impossible to create conditions by which it can be conclusively proved.)
- (d) That signs of widespread trouble began to come in during October from practice firing by units; but that prior to this there had been trouble in various tests at Lulworth.
- (e) That the trouble was initially the breaking of the S.A. cam, but that when the cams were strengthened (by redesigning the shape and ensuring better heat treatment) so that they did not break, the strain was shifted on to the bracket and caused distortion in this. This involved redesigning and strengthening the bracket.
- (f) That distortion of the bracket occurred in firing trials (on the 28th December, 1943) at Lulworth and went so far as to bring the firing gear into operation, thus causing a serious accident, which involved the permanent disablement of the officer in charge of the Development Wing.
- (g) That the bracket in the trial referred to in (f) was made of fabricated mild steel, thus apparently representing an attempt at strengthening the originally approved design, but an attempt which did not go far enough.
- (h) That, apart from faults in design, there have been faults in manufacture and material. Thus it has been stated—
 - (i) That a large number of broken cams showed clearly that the heat treatment had been faulty.

* According to the War Office Memorandum, the first tank mounting this gun was delivered to the Service on 11th October, 1943.

- (ii) That a contributory cause of trouble has been the difficulty of getting sufficient supplies of $3\frac{1}{2}$ per cent. nickel steel, which is required for these cams.
- (iii) That some of the brackets which showed deflection on firing were made of faulty material—in fact, of what has been described to us as "bedstead brass" instead of manganese bronze as specified.

(iii) *Practical conclusions from the failure.*

34. To arrive at a sure and precise judgment on all the issues involved would require an elaborate enquiry with expert assistance. This we have not attempted, since, whatever the exact technical explanation of what has happened, it seems to us that certain practical points emerge which admit of no reasonable doubt. The following are the main points relevant to the present enquiry:—

First.—It was sought to accomplish the task of carrying the 75-mm. gun in British tanks with a mounting which was less robust than that used for the equivalent gun in the Sherman. If, as is now alleged, inaccuracies of American ammunition have been the main cause of the failure, that factor ought to have been provided against from the outset, since this inaccuracy is well known to every soldier who has used any kind of American ammunition in operations or training. To choose a less robust mounting was, in any case, to take a risk which could only be guarded against by special care in the design and materials used. This care does not seem to have been taken. If a combination of fighting experience and technical knowledge had been brought to bear on the original design, such a mistake ought to have been avoided.

Second.—The tests and trials, on the strength of which the original design was passed for production, seem to have been confused and have proved by results to have been inadequate. It appears that trials were taken into account which were carried out in artificial conditions and with mountings of a design different from that first selected for production. There seems to have been no decisive occasion when an attempt was made to reproduce service conditions and deliberately to reveal weaknesses and break break down the mounting. That such a final test, under the combined supervision of technical experts and officers with practical knowledge of battle conditions, should be carried out before production contracts are placed seems to us to be essential.

Third.—The arrangements for manufacture seem to have been such that parts of the mountings were, in a number of cases, made of faulty material, improperly treated and finished. It is extremely disturbing, first, that manufacturers capable of such work should have been selected for making vitally important parts of war weapons, and secondly, that such faults should not have been detected on inspection.

35. These conclusions seem to us to show that there has been something seriously wrong either with the organisation itself or with the discharge of the responsibilities which exist under it. Our impression is that there has been a combination of both. So far as concerns organisation, this is one of the cases which appears to illustrate the dangers of the splitting of responsibilities. In regard to guns, we understand that the responsibility of the D.G. of A. for development (research, design and experimentation) and inspection is limited to the gun itself (the tube and breech mechanism) and its ammunition. His "frontier" of responsibility now stops there, though formerly it went further so as to include the recoil system and the cradle. We have been informed that this division has led to difficulties in the past, but that in recent months collaboration between the parties on both sides of the "frontier" has been considerably better. We hesitate to express views on these extremely technical matters, but we find it difficult to avoid the impression that this splitting of responsibility has contributed to results such as those now under consideration.

36. The conclusions in paragraph 34 also reinforce what has already been said as to the need for careful selection of contractors and for improving standards of workmanship, materials and inspection. We may add that we have had other evidence of faulty workmanship in the manufacture of tank armament. The experience of the Gunnery Wing at Lulworth is that the finish

of guns generally is poor, and that no less than one in three of the firing mechanisms of the 75-mm. M.V. gun received at the Gunnery School has had to be stripped and fitted by hand to make them interchangeable.

Main Conclusions.

(1) DEFECTS IN ORGANISATION.

37. Our conclusions from the foregoing review are that the new organisation has not fully "made good," and that the expectations recorded in the earlier Report (Eighteenth of 1941/42) have not been fulfilled. We do not wish to belittle the improvement which has taken place in the clarification of responsibility, in co-operation between the various branches, and in the leading personalities; but, in our view, there is still urgent need for further improvement. It appears to us that since the appointment of Major-General Briggs, with his recent fighting experience, at the War Office, and of Mr. Gibb at the Ministry of Supply, there have been definite signs of better working. We believe, indeed, that the course of events might, in several respects, have been different if these appointments have been made earlier; but we cannot, a second time, be content to recommend waiting to see what the "new men" can do, since, in our view, it is now demonstrated beyond question that the organisation itself is seriously defective.

(2) THE DISPERSAL OF RESPONSIBILITY.

38. The chief cause of trouble remains the familiar one of the division of responsibility which exists between—

The War Office (representing the users who want instruments of war for certain purposes);

The Ministry of Supply which has to interpret the wants of the users in terms of instruments capable of manufacture and to place the orders for their manufacture; and

The Manufacturers who have to carry out the orders.

The essential needs are—

(A) A clear conception by the General Staff of their requirements, *i.e.*, of what type of tank they will require *at the time when that tank will be available in production* (which means, if it is a new type, about two years ahead).

(B) A linking up of the responsibilities for achieving results approaching as nearly as is practicable to the requirements as defined under (A). This means responsibilities for—

- (i) The assessment of what is practicable, in design and production;
- (ii) The formulation of programmes of design, development and production, on the basis of (i);
- (iii) The execution of such programmes (including inspection and testing of what is produced).

39. As is shown by our recommendation in paragraph 53 we consider that the right arrangement in principle is that there should be a single overriding responsibility, and that this should rest with the War Office as the authority that has to stand or fall by the result.

40. So long, however, as the responsibilities and functions are kept separated, then at least everything should be done to reduce the effects of this separation to a minimum and to ensure that the three main agents work together in the closest partnership in such a way that each feels responsible for the whole combined operation of the partnership. The three partners should, in fact, be jointly and severally responsible for the results.

We cannot believe that many of the things which have happened in the past could have happened if this joint and several responsibility for results had been a reality.

41. In spite of all that has been done to improve the position in the last twelve months, our evidence shows only too clearly the dangers of divided responsibility between three agents—with each of the three able to shift on to one of the others the responsibility for any failure in the joint result. Moreover, this dispersal or confusion of responsibility seems to exist, not only as between the three main agencies, but also within the organisations in the War Office and the Ministry of Supply. Our impression of the present set-up is indeed that "alibis" for failures in results can far too easily be produced by everyone concerned. We have tried to form a fair judgment on the past record, and our conclusion is that a certain measure of blame attaches to each of the three main agencies.

(a) *The War Office and the General Staff as Representing the Users.*

42. One great danger arising from division between the "user" and "producer" responsibilities, is that the "user" may not take full account of how long it takes to introduce new types or modifications or of the disruptive effect which these have on production in the case of a complicated construction such as a tank. He tends, therefore, not to make up his mind early enough and to be too ready to change his requirements according to changing experience on the fighting fronts. This tendency has certainly revealed itself in the actual course of events, and there is a substantial element of truth in the criticism made by one industrial witness that "development has proceeded in a series of short nervous little steps, each of which has been sufficient to disrupt production; but no one so far has had sufficient courage, or been able, to assess the battle requirements sufficiently far ahead to make a technical jump that is going to put us ahead of the Germans."

43. It seems, further, that the General Staff have not been sufficiently decisive in stating their requirements or in choosing between the various practicable alternatives,* and facing the consequences. They also appear to have been too ready to take the attitude *vis-a-vis* the Ministry of Supply, "We say what we want and they say what they can do and then they get on with it, and after that our responsibility ends." In dealing with new ideas for tanks this implies a dangerous over-simplification both of the problem and of the soldiers' responsibility. Past records show that in converting tank requirements into production there is never a clear run. All sorts of unexpected difficulties crop up and fresh decisions have continuously to be taken. The Army side must constantly watch how things are going during the course of converting ideas into production, and it is for them, above all, to impart a sense of urgency to the whole process.

In recording the above remarks we have had in mind the general course of affairs over the past two years. One point in particular appears to be illustrated by what happened in connection with the A.34. On this matter there has been some conflict of evidence, but what chiefly impressed us was a statement from the General Staff side that it came as a shock to them when, some months after the idea had been mooted, they were informed that the improvement on the 75-mm. M.V. gun which they required (for which the "77-mm." was eventually adopted) would involve enlarging the Cromwell turret and, consequently, changing the hull to such an extent as to mean putting a new tank into production.

44. In stressing (paragraph 42) the importance of making plans far ahead and then adhering to them, we do not imply that short-range modifications and improvisations should not be made, since it is vitally important that the organisation should be tuned up to respond quickly, within the limits of what is possible, without disrupting the main flow of production. The need for replacing the 6-pr. with a better gun is a clear example of a short-range alteration which, as we have already strongly emphasised, ought to have been made much more quickly.† The need for knowing what is practicable in the way of improvisation, and imparting a sense of urgency to its accomplishment, is one of the strong grounds for establishing direct contact between the War Office and manufacturers and for giving the War Office the leading responsibility.

45. Finally, no arrangement for unifying responsibility, especially if that takes the form of placing the single responsibility on the War Office, can work

* In the perennial dispute between armament, armour, power-weight ratio, suspension, electrical fittings, and simplicity for production, the responsibility for settling the final balance of choice must rest with the General Staff.

† Incidentally, this case also illustrates the lack of forward planning, since the 6-pr. was practically obsolete as a tank gun by the time it reached the fighting formations in substantial numbers.

properly if the responsibility on the War Office side is itself confused or divided. Our impression is that at present there is a need for a closer linking-up between planning, training and operational responsibilities in connection with A.F.V.s and S.P. mountings.

(b) *The Ministry of Supply.*

46. In the case of the Ministry of Supply, one danger of the existing division of responsibility, involving their interposition as an intermediary between the user and producer, is that they may interpret the General Staff demands in a way which does not really meet the fighting soldiers' requirements. We have, however, in this inquiry been chiefly concerned with the results of the division of responsibility between the Ministry and the manufacturers. The point made by the latter is that a tank cannot be designed in a detached drawing office, but that at every step the designers must be in close touch with those who will have to execute the production. In the earlier Memorandum the Committee commented on the months which had been wasted in certain cases because modifications for meeting army requirements had been designed by the staff of the D.T.D., and then, when submitted to manufacturers, had proved to be quite impracticable as production jobs. They strongly recommended that manufacturers should be consulted from the outset and continuously. We have been glad to note that recently there appears to have been a marked improvement in this matter. In the case of the A. 34, for example, from the moment when the project was finally decided upon, the work of design was entrusted to the Leyland Company, and the D.T.D.'s branch, which has undoubtedly accumulated valuable knowledge, gave assistance by lending staff to work with Leyland's designers. This seems to us to be the right method, but even in this case our impression is that it would have been better from every point of view if the Leyland representatives had been brought into the discussions when the idea was first mooted in January 1943. We have, further, received evidence which indicates that cases still occur when time is wasted by design work being undertaken by D.T.D. without consulting manufacturers. We have been told, for example, that there has been a recent urgent demand for an all-round-vision cupola to be fitted on to all tanks; that D.T.D. prepared a design; and that the manufacturers found it had been done in such a way as to involve processes of production which, even if practicable, would have involved immense delay and unnecessary expenditure.*

As indicated in our recommendations, we adhere to the view expressed in the Committee's former Report that the leading manufacturers should be brought into still closer partnership in the responsibility not merely for design, but also for suggesting new ideas.

(c) *The Manufacturers.*

47. In the case of the manufacturers, the danger of division of responsibility is that they may not feel responsible *for results*. The present position is in effect that they are told to do a job according to a certain design and that it is not their business to express their ideas as to whether it is likely to be suitable for the task required. If it fails in this, they can wash their hands of responsibility. We cannot help comparing this position with that of the aircraft industry. When a Lancaster bomber goes into the air, the reputation of A. V. Roe and Company and, indeed, of the whole Hawker-Siddeley Group goes with it. There is no full parallel in the case of tanks. Possibly the Vauxhall Churchill and the Valentine respectively, and it is significant that these have been the most successful British tanks. But in the case of cruiser tanks there has never been a clear identification of a particular type with a particular firm, proud of its reputation, and it would be extremely difficult to make an affiliation order for the Cromwell or any of its relatives.

We believe that this consideration is of real importance and that it has something to do with the share in the blame for bad results which is attributed to faulty workmanship by manufacturers.

* Evidence from manufacturers indicates that the complaints about ideas being developed in detachment from the practical experience of the main tank producers apply not only to the work done under the D.T.D., but also to the Ministry of Supply establishment at Belper. This, it is alleged, has been another illustration of a dispersal of responsibility for design and of the introduction of confusing influences. We understand that arrangements which have recently been made, and especially the appointment of Mr. Gibb as Director-General of Armoured Fighting Vehicles, are likely to clear up these confusions. Accordingly, we have not enquired in detail into these aspects of the position.

(d) *Faulty Workmanship.*

48. Faulty workmanship, however, which must be considered together with faulty materials and inadequate inspection, represents a trouble involving a number of different causes and responsibilities. This has already been made clear by the illustration considered in paragraphs 23-29. It should also be noted that this matter is closely connected with design, and that if a designer is set tasks which require standards of accuracy and quality in workmanship which cannot reasonably be expected from manufacturers working with diluted staffs in war conditions, it is not fair to put all the blame on the latter. The story of British cruiser tanks and their armament seems to justify the comment that, before blaming the British workmanship, designers should devote more thought to the task of evolving simple and robust designs. The reliability of the Churchill as now evolved, as well as of the Valentine, seems to show that it can be done.

49. For the reasons given in the preceding paragraph we cannot accept without qualification the statement made to us in evidence by the General Staff that poor quality in the actual processes of manufacture has been a greater cause of trouble than any faults of design or vacillations in the programme. Such a statement is an over-simplification in the apportionment of blame. Nevertheless, we are satisfied that faulty workmanship, particularly in the products of certain firms, has been a substantial factor in the past, and we attach great importance to the conclusions on this matter which we have stated in paragraphs 22 to 36. We wish to emphasise most strongly our view that there is still an urgent need for improvement in standards of material, workmanship and inspection. We consider that drastic action should be taken in specially bad cases of carelessness in manufacture, and we trust that special attention will be given to our recommendations covering these matters.

(3) *Lack of Urgency about the Tank Programme.*

50. There is one further general consideration to which we feel bound to call attention. We cannot avoid the impression that, owing to the availability of large supplies of American tanks, which were regarded by the General Staff and the fighting troops as satisfactory, there has, as a matter of general policy, been some weakening of urgency and drive behind the whole of the British programme. This is not easily demonstrable by specific examples, but is rather an impression of general atmosphere which appears to have been felt throughout the industry. As one specific illustration, we have had evidence that in the matter of priorities as regards labour—particularly in the case of sub-contractors—those responsible for the Meteor engine programme have at times suffered appreciable delays.

(4) *General Observations.*

51. At the beginning of this Memorandum we referred to the prevalence of unfavourable comment upon British tanks. Although this is not a matter of expenditure, we cannot close without expressing our serious concern about this aspect of the position. It is not too much to say that there is a widespread feeling of depression about the situation. This is not an example of normal British grumbling or of complaints confined to the type of men who are naturally inclined to discontent and defeatism. It is impossible to probe anywhere, even among troops of the highest morale and fighting quality, without finding it. In our view, this is a very serious matter and urgent consideration should be given to devising means for dealing with it. It is not easy to make positive recommendations as to what should be done. The only really effective remedy would be the actual production of a British tank which proves its reliability and fighting value in action, and much will depend on the qualities shown by the first batches of the 1944 Cromwell tanks. But there are many things which clearly should *not* be done. Some of these are apparent from what has already been said. In this connection a particularly important factor is the training at the A.F.V. School at Lulworth, since a great many officers and other ranks pass through courses here. We have already commented on the bad effect of training pupils at the School on equipment which they know to be faulty or incomplete. We consider that these matters require special attention.

Recommendations.

(1) THE IMMEDIATE EMERGENCY.

52. As a preliminary to our general recommendations, we wish to represent one matter of immediate urgency. At this critical moment when British troops are about to be sent into action for the first time with Cromwell tanks there should be a concentration of every available resource so as to ensure that, so far as concerns quality of material and workmanship, nothing is left to chance. Requirements in respect of these first issues of Cromwell tanks should have super-priority and be subjected to specially rigid inspection. It seems to us to be of supreme importance that when the Cromwell tanks are first tested in battle they should not fail in reliability. If they do fail, then, after the unfortunate experiences of the past, it must be very doubtful whether the British cruiser tank will ever be able to regain the confidence of the troops.

(2) GENERAL RECOMMENDATIONS.

53. We put forward the following general recommendations:—

Organisation and Responsibility.

(A) The responsibility for obtaining production of technical instruments of war, such as tanks, should rest with the War Office. The transfer of responsibility to the enormous organisation of the Ministry of Supply has revealed most serious disadvantages. These disadvantages have not been confined to tanks, but have been evident throughout the whole field of technical stores.

(B) Pending the full implementation of the change recommended in (A), every possible step should be taken to create a close partnership in responsibility between the three main agencies—the War Office, the Ministry of Supply and the manufacturers, and to give the dominating position in this partnership to the War Office, seeing that it is they who are chiefly concerned with the practical results and who ought to be directly conscious of their urgency. It is not easy to devise the best method for achieving this purpose, but we put forward the following suggestions as indicating the kind of changes which in our view are necessary:—

- (i) The Tank Board should be made a more effective executive instrument and should be so constituted as to recognise that it is for the War Office "to call the tune."

At present the Board appears to have drifted into the position of a body for recording decisions reached by discussions at lower levels. There are too many separate pockets of responsibility in regard to tanks, their guns, their other equipment, and the whole range of S.P. mountings. The Tank Board should be made more effective in pulling these things together.

The Tank Board should be as small in numbers as possible.

The Chairman of the Tank Board should be a War Office representative, and on the War Office side there must always be adequate representation of recent tank-fighting experience.

On the Ministry of Supply side, the C.A.F.V., or the D.G.A.F.V., as "managing director," for organising the production of tanks and their equipment, should be given full responsibility for taking the steps necessary to give effect in terms of production to the decisions of the Tank Board.

We still consider that, as formerly recommended, there would be advantages in having the D.G. of A. as a member of the Tank Board.

- (ii) The representatives of a few selected industrial firms should be brought in to all discussions from the very first moment when a new idea is mooted. The manufacturing responsibility has now, after four and a half years' war experience, been sorted out, and according to our reading of the position, it would be sufficient for the purposes of this recommendation to include representatives of three firms—Vauxhall, Leylands and Vickers. Their representatives need not be members of the Tank Board, but they should normally attend all its meetings. No design work should be entrusted to D.T.D. without simultaneous consultation with the industrial representatives.

- (iii) When it is decided that a new type of tank is to be developed and put into production, the responsibility for parentage (including design, co-ordination of production and future development) should from the outset be given to a manufacturing organisation of proved efficiency with an adequate team of engineers. The functions of the C.A.F.V. (through D.T.D. or otherwise) should thereafter be to assist the parent's designing staff, rather than to work independently on any feature.

(C) The organisation on the War Office side requires in any case to be made more effective. The main objectives should be—

- (i) To bring about, in the case of A.F.V.s and S.P. mountings, a closer unity of the responsibilities for—

the formulation of requirements;
the conduct of tests and trials before designs are approved for production;
the subsequent supervision of production programmes;
all matters concerning the handling of A.F.V.s and S.P. mountings after issue to units, including training.

- (ii) To ensure that officers with recent operational experience are in contact with all stages.

We deliberately leave this recommendation in general terms; but, as one instrument towards attaining the foregoing objectives, we have been impressed with the value of suggestions that have been put before us by various witnesses for the formation of a comprehensive Tank Centre. Such a Centre would be organised so as to ensure adequate facilities for comprehensive tests, covering gunnery, driving, maintenance, wireless equipment, &c. We are strongly impressed with the disadvantages under the present system arising from the splitting up and duplication of various tests. The regular provision of an adequate supply of prototypes and of the latest production models to the Central Tank School would be an important feature in any such arrangements (see paragraph 51).

Workmanship and Inspection.

(D).—(i) Every possible step on the lines indicated in paragraphs 23-29 should be taken to ensure first-class standards in materials, workmanship and inspection (both by I.F.V. and by manufacturers themselves) in tank production. The inspecting staff at I.F.V. should be drastically overhauled, and members of the staff with insufficient experience should be replaced by men with the necessary experience who are at present either in industry or in the armed forces.

(ii) If manufacturers' inspection standards can be improved by taking men off production, then this should be done. It will be justifiable to face some sacrifice in quantity, if that is necessary, in order to ensure first-class quality. (This applies to manufacturers of components as well as to the main assembly firms.)

Priorities.

(E) There should be no doubt about adequate priority for everything that is involved in the agreed tank programme. This applies particularly to requirements for the Meteor engine programme which is the key to the whole British cruiser tank programme.

Links with Fighting Experience.

(F) Constant attention should be given to improving and simplifying the procedure for introducing minor modifications proved necessary by fighting experience.

54. The foregoing recommendations are not intended to be exhaustive; but as to the urgent importance of the objectives to which all of them are directed we are in no doubt. Unless determined steps are now taken for improving the organisation for Tank Development and Production, results like those of the past must be expected to recur with the consequence that money and war resources will continue to be wasted. Beyond this there is the serious danger that the country will, at the end of the war, find itself without a properly functioning

organisation for handling an extremely important branch of mechanical warfare. Such a deficiency may have incalculable consequences. That we should rely on American tanks to do the present fighting while we spend millions on making British gun-tanks which are only suitable for training or conversion to other purposes is regrettable enough; but, looking to the future, it would be a national disaster if the present reliance on American tanks were allowed to dull the Government's recognition of the vital need for building up a first-class organisation and production machine for developing British armoured fighting vehicles.

9th March, 1944.

II.

MEMORANDUM TO THE PRIME MINISTER BY THE MINISTER OF PRODUCTION.

1. The Secretary of State for War, the Minister of Supply and I have considered the Secret report on Tank Production which the Select Committee on National Expenditure sent you on the 11th March. The following observations and the other documents enclosed with this minute have been agreed between us.

GENERAL.

2. The Select Committee's report is diffuse and full of repetitions. It seems clear (a) that the Committee cannot have had adequate evidence on which to base certain of their more important conclusions and (b) that on a number of technical matters they have formed erroneous impressions either by reason of the complexity of the subject or through their acceptance of evidence from outside sources without checking this information with the Departments.

3. The Committee gives an account of the results of tank production in 1943 compared with their impressions of what the programme was at the end of 1942. In doing this they attempt to measure what they call the "operational dividend" and give figures which purport to show that only 44 per cent. of the tanks produced in 1943 were "operationally adequate as gun tanks." The Committee's measurement of the "operational dividend" overlooks:—

- the fact that since Tunisia British troops have not been engaged in any fighting in which tank forces have been employed on any scale. If such operations had developed there is no doubt that a greater proportion of the 1943 output of cruiser tanks would have been used as operational gun tanks even though they were not of the very high standard of the present Cromwells;
- the need for tanks in large numbers for the training of troops. The Cromwells produced last year have been largely used for this purpose. Centaurs, which except for their engines are identical with Cromwells, have been most valuable for training, and have enabled the more valuable Meteor-engined vehicles to be reserved for operational use or for more advanced training. Many hundreds of Shermans have also had to be used; and
- the operational importance and urgency of the special rôles for which it proved possible rapidly to adapt the Crusader in particular.

4. The Committee express disappointment that it was not until the beginning of 1944 that Cromwells fully conforming to accepted operational standards were in quantity production, but they fail to appreciate that operational efficiency cannot be obtained in a completely new design of a weapon so complex as a tank without a long period in the hands of troops and progressive modification.

TANK ARMAMENT.

5. The Committee appear to think that the 6-pr. gun became obsolete at the end of 1942 and ignore the fact that for the armour-piercing rôle this gun remained throughout 1943 a standard general staff requirement for a considerable proportion of our tanks. The Committee's report was written without full knowledge of the latest types of special ammunition, which make this gun a formidable weapon.

6. The Committee give great prominence to the delays which occurred in producing the 75 mm. M.V. gun and particularly its mounting up to a state of operational efficiency. It is true that there were difficulties and disappointments. The normal precautions and tests were applied, but this is one of the cases where weaknesses were revealed in Service use which did not show themselves during acceptance trials. The gun was approved as a general staff requirement in January 1943, it began its tests in March and was issued to the troops in October. The faults which thereafter became evident were corrected by February 1944 and the improved model is now in regular production.

FAULTY WORKMANSHIP AND MATERIALS.

7. The Committee give a number of cases of faulty workmanship and materials and seem to have formed the impression that such faults are rife. Whilst it could not be claimed that tanks are or could ever be entirely free from this source of trouble, energetic steps have been taken by the Ministry of Supply and by firms progressively to tighten up inspection arrangements so as to reduce these cases to a minimum.

ORGANISATION.

8. The Committee's main recommendation is that the responsibility for obtaining the production of technical instruments of war, such as tanks, should rest with the War Office. This is under consideration by the Machinery of Government Committee as a matter of long-term policy, but it is agreed by all of us that such a complete reversal of the policy followed since 1939 is not justified at this stage of the war by anything that has happened since the new arrangements at the War Office and the Ministry of Supply were made in September 1942.

9. "Pending the full implementation of the change" the Committee urge that everything possible should be done to create the closest partnership between the War Office, the Ministry of Supply and the manufacturers, the "dominating position" being given to the War Office. The fact is that the contacts provided by the Tank Board, periodic meetings between directing personnel and the daily personal interchanges at all levels have achieved a very real integration of the efforts of the two Departments.

10. The Committee suggests that the Chairman of the Tank Board should be a War Office representative so as to give the War Office the dominating position. The realistic approach to this problem is to appoint the best Chairman available irrespective of the Ministry to which he belongs. Taking into account the personalities of the existing members of the Board and the fact that the sphere of executive action in production lies mainly with the Ministry of Supply, the War Office are satisfied that it is not desirable or necessary to ask for any changes.

11. The Committee makes a number of other recommendations, which are set out below with brief comments:—

- The D.G. of A. should be a member of the Tank Board. This has now been agreed.
- The fullest possible responsibility for tank design should be placed on selected parent firms. This is fully endorsed by the Ministry of Supply, and indeed it is their established policy and is well understood by parent firms.
- The Ministry of Supply should not themselves undertake design work, but they should assist the parent firms' designing staff rather than work independently on any feature. The fact is that with a single exception, viz., Vickers, none of the firms concerned in tank manufacture has the specialist resources necessary to handle many of the design problems connected with the fighting qualities of tanks, e.g., those relating to armament, armour protection, &c. On such matters they must, therefore, look to the Ministry for a large measure of help.
- Representatives of selected parent firms should normally attend meetings of the Tank Board. This is already done from time to time when occasion warrants, but it is not considered necessary or desirable that they should regularly attend all meetings.
- There should be an improvement of the organisation within the War Office and the establishment of a Tank centre with facilities for

comprehensive tests, covering gunnery, driving, maintenance, wireless equipment, &c. There is already a complete unity of responsibility in this field under the D.C.I.G.S. The arrangements between the Ministry of Supply and the War Office for carrying out trials and tests are working smoothly and, with the exception of facilities for gunnery trials, the establishment at Chobham fulfils the requirement. An entirely new Centre with facilities for all types of trials, embracing those undertaken at Chobham, Shoeburyness and Lulworth, would not be justified at this stage of the war.

- (f) The links with fighting experience should be strengthened. Much attention has been given to this subject. As far as possible officers with recent operational experience are kept in close contact with all stages of development. Extensive military technical services are maintained by the Ministry of Supply in all overseas theatres of war. These services act as a direct link between troops in battle and the design and production organisation.

12. No one would quarrel with the view expressed at the end of the Committee's report that it would be disastrous if this country, as a result of undue reliance upon America were to fail to build up a first-class organisation for producing tanks. With the growth of experience in industry and in Government establishments this objective is being progressively achieved.

13. Following the precedent established on the last occasion, I enclose for your consideration—

- (a) A draft of a letter for you to send to Wardlaw-Milne; and
(b) A memorandum of reply to the Select Committee for enclosure with that letter.

O. L.

20th May, 1944.

DRAFT LETTER FROM THE PRIME MINISTER TO SIR JOHN WARDLAW-MILNE,
K.B.E., M.P.

I have now received and considered the comments of the Departments concerned upon the Memorandum on Tank Production which you sent me with your letter of the 11th March and which I have read.

Your Committee will, of course, realise that it was not possible to give them a detailed reply in the interval between the receipt of their memorandum and the Secret Debate on tanks which took place in the House of Commons on the 24th March.

Although a good deal of the ground covered in the memorandum was traversed during the debate, I feel that the interest which your Committee has taken in this important topic merits a reply more particularly directed to their findings and recommendations. I have accordingly had the enclosed memorandum prepared for them.

There are one or two general observations which I wish to make. Satisfactory American tanks were available in adequate numbers during 1943 and British troops were not engaged in large-scale tank operations after the Tunisian campaign. These two factors removed, for the first time since Dunkirk, the fear of a quantitative deficiency which had previously prevented development of tank design and production on the lines we should have followed had we been free to do so. The situation in 1943 enabled a drastic reshaping of our tank production policy and this accounts in large measure for the fact that 1943 output fell substantially short of the estimate made at the end of 1942.

The Minister of Production, the Secretary of State for War and the Minister of Supply have, during 1943, kept jointly under review the working of the new organisations which were set up at the end of 1942 and are satisfied that they are functioning efficiently and smoothly. The Ministers have advised me that in their opinion it would be unwise at this stage of the war to hand back to the War Office the responsibility for obtaining the production of all technical stores including tanks. I agree with them that such a major reversal of policy at this date would not be practicable or justified by anything that has happened in the last eighteen months. This is a matter of long-term policy to which full consideration will be given.

I note that your Committee had it in mind to present a further report to the House of Commons. Whether they will think it necessary to do so now in the light of what was said during the Secret Debate and of what is said in the enclosed memorandum is, of course, a matter for them to determine. But if they do decide to publish a report I would ask them to weigh their words with a full sense of responsibility at a time when great events are impending.

DRAFT REPLY TO THE MEMORANDUM ON TANK PRODUCTION BY THE SELECT
COMMITTEE ON NATIONAL EXPENDITURE.

I.—THE RESULTS ACHIEVED IN 1943.

(A) *General Comment.*

1. The Committee record their general impression that 1943 results, measured in terms of tanks fit for current battle requirements, have fallen far short of expectations, and been wasteful of expenditure.

2. It is true that some of the expectations that existed at the end of 1942 have not been realised in 1943, but the availability of American Sherman tanks in considerable numbers, and the pause in tank warfare since the end of the Tunisian Campaign have given an opportunity of overhauling our tank production policy and placing it on a sounder footing. These two factors removed, for the first time since Dunkirk, the fear of a quantitative deficiency which had previously prevented development of tank design and production on the lines which, but for reshaping of our tank production policy, and this accounts in large measure for the fact that 1943 output fell substantially short of the estimate made at the end of 1942.

3. As regards expenditure, the Committee claim that tanks cost the Ministry of Supply 18.79 per cent. of their total expenditure on war-stores during 1942-43. The figure actually supplied by the Ministry of Supply and correctly quoted by the Committee in Appendix I to their 14th Report was 17.69 per cent. But this related not to expenditure on tanks, but to orders placed for tanks and all tracked vehicles in the year 1942-43. Expenditure on tanks as such represented 9 per cent. and 18.79 per cent. of the Ministry's total expenditure in that period.

(B) *Prospect v. Performance.*

4. The main points to be noted are:—

- (a) That the Crusader chassis proved suitable for special operational rôles, for which no other existing chassis was available.
(b) That the General Staff do indeed require Churchills as infantry tanks, and they are now in use in Italy.
(c) That the Cromwell would have been used, if it had been required in 1943; but since there was little tank fighting and Shermans were available, opportunity was taken to submit it to prolonged tests and modification in order to bring it up to the present high standard.

(C) *The Operational Dividend.*

5. On page 5 of the Report the Committee gave a table in four columns purporting to show that the *operational* dividend in gun-tanks was nil in the case of all tanks except Valentines and Churchills and a few Matildas. This by itself is somewhat misleading. If there had been major tank battles since Tunisia, the picture would have been quite different.

6. Moreover, the Committee's conception of "Operational Dividend" takes no account of the need for large numbers of tanks for training, which is itself an important operational requirement. The 1943 Cromwells have been largely used for this purpose and the Centaurs, which, except for their engines, are identical with Cromwells, have been most valuable for training, and have enabled the Meteor-engined Cromwells to be reserved for battle-tanks or more advanced training. It is relevant to note that many hundreds of Shermans have likewise had to be used for training.

7. The Committee also do less than justice to the importance and urgency of the special operational rôles for which Crusaders in particular have been

adapted. Vehicles for these purposes could not have been obtained nearly so quickly or economically had they had to be specially designed as the Committee appear to recommend (Report, paragraph 19). Special designing and switching over of production to a new type might, indeed, have taken 2 years or more.

8. With these considerations in mind, the correct heading for the third column of the table should have been "Operationally used as gun-tanks." The table would then be substantially correct, though it would not prove the Committee's contention.

II.—THE FUTURE PROGRAMME.

9. Under this heading the Committee make several comments on armament development which can be more appropriately dealt with below in section III of this Reply devoted to armament questions.

10. On the *Cruiser tank* programme the Committee comment on the tailing off of the Cromwell production after mid-1944. Some tailing off will occur, but there will still be substantial production of Cromwells throughout 1944, and maybe into 1945. The A. 34, which will eventually supersede the Cromwell, should not have the serious teething troubles which the Committee expect, as it is based upon and follows closely the now reliable Cromwell design.

11. The Committee's remarks on the Churchill developments are substantially correct.

III.—DEVELOPMENT OF ARMAMENT.

12. Under this heading the Committee comment on the impressions of delay and failure which they sense in the development of a satisfactory tank-gun.

(a) *The 6-pdr. gun.*

13. The Committee claim that, owing to its ineffective H.E. shell, this gun has been considered inadequate as a general tank gun since December 1942, and they ask why there has been so long a delay in replacing it by the 75-mm. gun (paragraph 19). The fact is, however, that the 6-pdr. remained throughout 1943 a standard General Staff requirement in the armour-piercing rôle for an appreciable proportion of tanks.

(b) *The 77-mm.*

14. The Committee recognise that this gun will give a better A.P. performance than the 75-mm., but state that the gun has not yet been produced and fired and its H.E. ammunition design is still under discussion. This may have been true at the time the Report was written, but both gun and gun mounting had been produced and passed its C.I.A. test some considerable time before the Report was issued; the design of the H.E. projectile, also, is completed and the ammunition will be available when required.

(c) *The 75-mm.*

15. The Committee devote a considerable portion of their Report to the story of this gun and its teething troubles, and they claim (paragraph 13)—

- (i) That there was delay in getting this gun with a serviceable mounting fitted to Cromwells and Churchills.
- (ii) That a design for mounting, which later proved dangerously inadequate, was approved for production.
- (iii) That tanks were issued to field formations with the defective gun mountings and that this had a bad effect on morale, as warnings had to be given.
- (iv) That officers going through the A.F.V. school have had to be instructed on gearing known to be defective.

16. The official General Staff policy on tank armament during 1942 required the tank gun to be a first-class anti-tank weapon and, secondarily, as effective as possible against personnel and lorries. Battle experience at the end of 1942 and evolution of tank tactics caused a change and on the 3rd January, 1943, the General Staff laid down that the main armament of the greater proportion of medium tanks should be an effective H.E. weapon, and, secondarily, as effective as possible against enemy armour. The rest were to have an armour-piercing weapon of high performance—at that time the 6-pdr.

17. The Ministry of Supply proceeded without delay to develop the 75-mm. gun. It is the case that there were difficulties and disappointments. The new gun began to be issued to troops within 9 months of the decision to adopt it (i.e., in October 1943). However, after its introduction into the Service, weaknesses in the semi-automatic gear became apparent and to overcome these important modifications had to be introduced. To say that the consequent delay could have been avoided by more extensive trials is to argue backwards. Trials were carried out on the normal scale which has proved adequate for other guns and this is one of the cases where weaknesses were revealed in service use which were not shown up in acceptance trials. The necessary modifications were rapidly introduced and the 75-mm. guns with modified mountings were in regular production by February 1944.

18. In paragraphs 30–33 of their Report the Committee endeavour to assess the factors which have contributed to the disappointments that occurred in the case of this gun. The Committee themselves clearly recognise that the matter is one involving complicated technical issues. While not agreeing with all the inferences drawn by the Committee, it is true that mistakes were made and wrong materials used and steps have been taken to ensure that the lesson will be applied in the conduct of future trials, and in production.

19. As regards the Committee's "practical conclusions from the failure" (paragraph 34), the following points may be made. The normal tests were carried out. The design was carried out by the Technical Department of D.T.D. with full knowledge of the problems concerned. The trials were carried out under the supervision of C.I.A. and gave results which were considered satisfactory, and these results were confirmed at the trial carried out at Lulworth in the summer. These trials were conducted by a combination of D.T.D. and the Experimental Wing of the War Office Tank Gunnery School. Officers with recent battle experience were present at the Lulworth trials.

20. The Committee also comment on the danger of split responsibility (paragraph 35), the D.G. of A.'s responsibility being limited to development and inspection of the gun itself and its ammunition. The line, however, must be drawn somewhere, and it should be noted that the relation of the gun-mounting to the turret and fighting compartment is even closer and more complex than the relation of the gun to the mounting. The addition of the D.G. of A. to the Tank Board will assist the smooth working of the machinery for co-operation.

IV.—THE SIGNIFICANT POINTS IN THE RESULTS OF 1943.

21. The Committee pick out as outstanding "faulty appreciations" at the end of 1942:—

- (a) The decision "to put all eggs into one basket" and concentrate on a still unproved type of cruiser tank (the Cromwell).
- (b) The decision to continue to rely for the major part of the programme on an engine (the Liberty) which on past performance was proved inadequate.
- (c) The decision regarding the parent firm for the Cromwell.

22. On these the following comments are made:—

- (a) The decision to press forward with the Cromwell against a background of available Shermans has been fully justified.
- (b) The Liberty engine had to be used at the outset of 1943 because no other engine of sufficient power was developed and capable of being produced in adequate numbers for the tank programme then contemplated. On the basis of a decision taken in September 1942 the Meteor capacity was expanded with the greatest speed that circumstances allowed, but this expansion could give no yield of complete engines in 1943.
- (c) The Committee have apparently misunderstood the history of the Cromwell parentage. It was the declared intention of the Ministry from an early stage to entrust the parentage of this machine to the Vauxhall firm as soon as their commitments in respect of the Churchill were permitted. In pursuance of this policy the Vauxhall firm were associated with development work on the Cromwell from an early

date and actually built several prototypes. When, however, it became necessary to continue the production of Churchills and to embark on further development of this type of Infantry tank, it was clear that the Vauxhall firm could no longer undertake the parentage of the totally different Cromwell. Steps were therefore taken as early as possible to bring to an end the arrangements—which had always been regarded as provisional—under which the Birmingham Railway Carriage firm had acted as temporary parents, and to transfer the parentage formally and finally to Leylands.

23. The following are the specific answers to the questions posed by the Committee in paragraph 19:—

(a) Could not the decisions reversing earlier policy (*e.g.*, as regards the Meteor engine programme) have been taken earlier?

(b) Has it really been necessary, for the sake of avoiding dislocation in employment, to continue the production of obsolete or condemned types of vehicle and engine so long as has been done?

(c) When it was decided that certain tanks (Crusader, Cavalier, Centaur) must continue in production even though they would not be accepted as gun-tanks, was the task of preparing all the modifications and appliances which would be necessary for their alternative uses undertaken with sufficient vigour and foresight? We understand, for example, that the production of Centaurs as gun-tanks has been continued much longer than was intended because the fittings and modifications required for using them as A.A. tanks were not ready. Our evidence also suggests some confusion as regards the equipment and uses of O.P. tanks.

(d) Lastly, and most important, the question already referred to: why has there been so long a delay in replacing the 6-pdr. with the 75-mm. gun?

24. The Committee's comments on the future programme for Cromwells and A. 34's in paragraph 20 of the Report are answered in paragraph 10 above.

25. Under the heading of "the inescapable facts" the Committee record the following impressions of the general results of the production story in 1943:—

(i) That, apart from the Valentine used in Russia and the Churchill in Tunisia, no British tanks during 1943 have been considered worthy of a place in the main battles.

This is answered in paragraph 5 ff. above.

(ii) That British tanks issued to British troops have gained a bad reputation both for mechanical reliability and fighting arrangements.

This is a sweeping statement which fails to take into account the situation which this country found itself in after Dunkirk and of the many difficulties that have had to be overcome since then.

(iii) That British factory workers have seen very large quantities of completed tanks broken up or parts (finished and half finished) piling up to be taken away as scrap.

(a) No. The decision to develop Meteor capacity independent of aero-engine capacity was taken at the earliest moment at which it could be implemented, *i.e.*, September 1942.

(b) Even assuming that the vehicles referred to were fully obsolete or condemned (which is not true), abrupt termination of programme would have disrupted the production organisation of manufacturers to an extent which would have crippled the further production of tanks in this manufacturing capacity.

(c) Yes. When a decision was taken to discontinue the use of a model as a gun-tank, no avoidable delay in stopping production of such gun-tanks occurred. Production of chassis necessarily continued in advance of the supply of fittings required for special rôles, which fittings frequently involved novel and complex design and production problems.

(d) This question has been dealt with above (paragraph 15 ff.).

This ignores the fact that after Dunkirk tanks had to be produced in numbers suitable at any rate for home defence in a time of desperate emergency. Such tanks fulfilled this purpose and also a useful training rôle, but it is not surprising, and should not be a reflection on the organisation in 1943 that Covenanters and Matildas of 1940-41 now have to be scrapped. The inference from the Committee's statement that it is quite common for British workers to complete tanks and then see them broken up before being used is wrong. No finished tanks have been broken up before they have completed a considerable mileage in training and other uses.

(iv) That these things have combined to create a most unfortunate psychological atmosphere amongst workers and troops, which deserves the urgent attention of the War Cabinet.

Although such an atmosphere may unquestionably be encouraged by irresponsible public criticism, those who are directly and continuously in touch with the workers on the one hand and the troops on the other are not prepared to subscribe to the views expressed by the Committee. A great deal of reassurance has been given by recent developments.

V.—LESSONS FROM SPECIAL CASES.

26. The Committee comment in some detail on the lessons to be learnt from a short preliminary report they have seen about the 3,000-mile reliability trial.

27.—A. The trials are said to have brought to light a few serious design defects, but "a lot of very serious manufacturing faults."

It is admitted that in some cases faulty materials and workmanship have found their way into completed tanks. Every effort has been, and will continue to be, made to eliminate them, and complaints of this sort have been greatly reduced. It is believed that the inspection system which has been built up and reorganised over the past year or more (see paragraph 41) will result in a continued improvement. Isolated cases of faulty workmanship and materials are liable to be exaggerated, and to draw the conclusion that the tank programme as a whole is suffering seriously from such defects would be a gross injustice to the large majority of manufacturers and workpeople employed.

28.—B. Parent firms, although held responsible by the Ministry of Supply for the products of the whole group, have no established authority to control working methods of members of a group.

The principle underlying this comment may be sound, but its practical application is a matter of great difficulty. The principle of supporting the authority of the parent company is a matter to which the Ministry of Supply is devoting constant attention.

29.—C. It is important to use the greatest care in selecting sub-contractors.

This is agreed, but it should be remembered that the rapid expansion of the tank industry took place after the expansion of both naval and aircraft production and at a later stage of the general expansion of munitions production, so that a number of firms who might have been the most suitable for many important tank components were not available.

30.—D. There is a shortage of qualified staff both for inspection by the I.F.V. and inspection by manufacturers themselves, and this can only be countered by (a) transferring selected R.E.M.E. personnel to the I.F.V. and (b) taking a certain number of trained personnel in the factories off production, if necessary facing a loss in quantity to secure a better guarantee of quality.

The shortage of trained personnel is admitted but it is an *overall* shortage (see paragraph 41).

VI.—CONCLUSIONS AND RECOMMENDATIONS.

31. Comments on the "Main Conclusions," and the "Recommendations," of the Report (paragraph 37 to the end) may conveniently be taken together.

A. The Immediate Emergency.

32. The Committee comment that it is of supreme importance that when Cromwell tanks are first tested in battle they should not fail in reliability and that requirements in respect of these first issues of Cromwells must have

superiority. Any failure of these tanks would, in the Committee's view, finally shake the confidence of British troops in the British cruiser tank.

This is accepted in full and every effort is being made to ensure that these tanks, when issued to operational troops, are in as perfect a condition as can be achieved.

B. Organisation and Responsibility.

33. The Committee set as their ideal objective the reunion under the War Office of all responsibility for obtaining production of technical instruments of war, such as tanks.

The Committee do not suggest in what way this transfer back to War Office would in fact meet the ills they describe. At this stage of the war retransfer of research design and production functions to the War Office would be little more than a nominal change since the same staff would need to be employed in more or less the same places. Most of the problems of responsibility and liaison to which the Committee draw attention would remain in what would inevitably be a vast production organisation under the War Office. In any case, now is not the time to undertake such a complete reversal of the policy followed since 1939.

34. Pending the full implementation of the change suggested in the preceding paragraph the Committee recommend that everything possible should be done to create a close partnership between War Office, Ministry of Supply and manufacturers, the dominating lead being taken by the War Office.

Such a partnership already exists and the War Office does in a real sense already occupy the dominant position since it is the customer and initiates the requirements. Full contacts are provided by the Tank Board, and at this level, as well as at all lower levels, a real integration of effort between the two Departments concerned has been and is increasingly being achieved.

35. The Committee claim that the Tank Board is becoming a less effective executive instrument than in the past. That is not so. The Board's executive authority is subject only to the agreement of the two Ministers concerned and of the War Cabinet where necessary. The Board's day-to-day decisions operate without let or hindrance. The executive functions of the Board are exercised primarily in the Ministry of Supply's province, and therefore the Committee's primary view of the Board should be a War Office representative may be questioned. It is the considered view of Departments that the realistic approach is to appoint the best Chairman available irrespective of the Department to which he belongs. It may be added that the War Office themselves do not desire a change in the present constitution of the Tank Board.

36. The Committee's view that the Tank Board should be as small in number as possible is accepted, as is their recommendation that the D.G. of A. should be a member of the Tank Board. Their recommendation that C.A.F.V. or D.G.A.F.V. should be given full responsibility in carrying out in terms of production the Tank Board's decisions is a reflection of present practice.

37. The Committee recommend that representatives of select parent firms should normally attend all meetings of the Board but need not be members. Such representatives have several times been invited to Board meetings to deal with particular problems, but it is not thought desirable or necessary that they should attend all meetings.

38. With regard to the recommendation that there should always be adequate representation of recent tank-fighting experience, it should be noted that the War Office representation on the Tank Board does at present include an officer with outstanding experience of such a kind.

39. Within the War Office the Committee recommend that there should be a closer unity of responsibilities and that officers with recent operational experience should be kept in constant contact with all stages. The unity of responsibility to which the Committee refer is in fact attained under D.C.I.G.S. for all things which are the province of the War Office.

With regard to the comprehensive Tank Centre which the Committee recommend, the arrangements between War Office and Ministry of Supply for carrying out tests and trials are working smoothly, and, with the exception of facilities for gunnery trials, the establishment at Chobham fulfils the requirement. An entirely new Centre, with facilities for all types of trials, embracing those undertaken at Chobham, Shoeburyness and Lulworth, would not be justified at this stage of the war.

40. The Committee consider (Report paragraph 47) that the present division of responsibility involves the danger that the manufacturers may not feel responsible for results, and they contrast this position with that in the aircraft industry where the reputation of the producer is closely knit with the performance of the plane. It is to counteract this tendency that the recommendation that members of three firms—Vauxhall, Leyland and Vickers—should normally attend meetings of the Tank Board is made (see paragraph 37 above). The Committee also recommend that immediately a new type of tank is decided upon, responsibility for parentage should be allocated to an organisation of proved efficiency with an adequate team of engineers and that thereafter no work on the designs and development should be done by Departments unless in co-operation with the parent firm.

It is accepted Departmental policy to entrust a new type of tank to a single manufacturing organisation of proved efficiency and thereafter to place the fullest possible responsibility for design on the selected parent firm. Only one firm, however, has the necessary specialist resources to handle many of the technical design problems relating to the fighting qualities of tanks and firms must therefore continue to rely on the War Office and Ministry of Supply for a great deal of help. It is in general not the practice of D.T.D. to work independently, but rather to assist the design staff of the parent firm and to work in close consultation with them. The Committee's observations in fact do less than justice to the help given by D.T.D. to parent design firms on the fighting side of tanks.

C.—Workmanship, materials and inspection.

41. The Committee recommend that every possible step towards improvement, where necessary, should be taken; that the inspecting staff of I.F.V. should be overhauled drastically; and that it would be justifiable to face some sacrifice in quantity of tanks produced in order to attain a higher quality and therefore if necessary recruitment for manufacturers' inspection staffs should be from the production lines (this applies also to sub-contractors.)

The need for strengthening inspection staffs has been fully recognised. Industry and the Armed Forces have been drawn on for recruitment of inspection personnel to the fullest extent possible and the numbers of technical staff employed on tank inspection work were doubled between November 1942 and March 1944. Man-power limitations are however very severe and the withdrawal of any substantial number of men from production lines or R.E.M.E. is by no means so simple as the Committee would suggest. Departmental policy, as developed in 1943, has been to emphasise quality rather than quantity in tank production, a change in emphasis then for the first time made fully possible owing to the circumstances outlined in paragraph 2 above.

D.—Lack of urgency: priority for the tank programme.

42. The Committee record (Report, paragraph 50) their general impression that owing to the availability of Shermans there has been a lack of a sense of urgency and drive behind the whole British tank programme. That there has been any such lack is denied. The Committee proceed to recommend that "there should be no doubt about adequate priority for everything that is involved in the agreed tank programme." Up to the autumn of 1943 the tank programme undoubtedly had a lower priority than aircraft, but since that date arrangements have been made in collaboration with the Ministry of Production for all essential parts of the tank programme to be given equal first priority.

E.—Lack of confidence in British tanks.

43. The Committee express the gravest concern that such lack of confidence is found even amongst troops of the highest morale. One positive remedy which they suggest is that the use of faulty or incomplete equipment for training purposes at the A.F.V. School at Lulworth should be given urgent attention.

The Churchill tank has proved itself, and there is every reason to believe that the Cromwell will do so in the near future. It is admitted that through force of circumstances some faulty and incomplete equipment has in the past been used at Lulworth. This has now ceased and no complaints are now being received.

F.—*Links with fighting experience.*

44. The Committee consider that the procedure for introducing minor modifications proved necessary by fighting experience should be improved. The Ministry of Supply, with War Office assistance, maintain in all theatres of war extensive military technical services which act as a direct and efficient link between the troops in the battle lines and the design and production organisations. Further methods of strengthening such links are continually being studied. Officers with recent operational experience are kept in close touch with all stages of development.

G.—*Result of failure to implement recommendations.*

45. The Committee finally conclude that unless determined steps are now taken to improve the organisation for Tank development and production, money and war resources will continue to be wasted, and, what is worse, there is a serious danger that the country will at the end of the war have no properly functioning organisation for handling this extremely important branch of mechanical warfare.

It is agreed that it would be a national disaster if the country were to fail during the war to build up a first-class organisation for producing British tanks. With the growth of experience in industry and in Government establishments this objective is being progressively achieved and the Committee need have no fear that every effort is not being exerted towards that end.

III.

LETTER TO THE PRIME MINISTER FROM SIR JOHN WARDLAW-MILNE, K.C.B., M.P.

SELECT COMMITTEE ON NATIONAL EXPENDITURE.

Dear Prime Minister,

10th May, 1944.

I am directed to ask you when the Select Committee on National Expenditure may expect to receive a reply to the Memorandum on Tank Production which they addressed to you for the consideration of the War Cabinet on the 11th March last. Since the House has been informed that the memorandum the Committee sent you was on this subject, the pressure on the Committee for a report to the House has been continuous and increasing. The Committee are fully alive to the heavy burden which lies upon the War Cabinet at the present moment and unwilling to add to it, but they cannot properly discharge the duty laid upon them of reporting to the House before they are in possession of a considered reply to their Memorandum.

Your sincerely,

J. WARDLAW-MILNE.

IV.

DRAFT INTERIM REPLY FROM THE PRIME MINISTER TO
SIR JOHN WARDLAW-MILNE, K.B.E., M.P.

The replies of the Departments concerned to the Memorandum of your Committee about Tank Production have now been received and will have to be considered by the Cabinet and by me. I regret I cannot hold out any hope that it will be possible to give you a final answer on this subject while the pressure upon the War Cabinet remains so severe and in the advent of the very serious operations which are impending. Later in the Session I should hope that it would be possible not only to give your Committee the reply to which they are entitled, but also to have a Debate in public upon the subject, in which it will not be necessary to insist upon those restrictions which required our Debate to be held in secret on the last occasion.

Gt. George Street, S.W.1

9th February, 1942.

Personal and
Secret

Handwritten signature

Mark IV (Churchill) Tank

I send you herewith 2 copies of the supplementary Report, a draft of which I had sent to Beaverbrook while he was still Minister of Supply and to which I have attached a copy of my preliminary Report as an appendix. I spoke to you about this on Friday last after the meeting of the Lord President's Committee here. I undertook the enquiry into the Mark IV (Churchill) Tank at Beaverbrook's personal request, and I should be glad, now that you have succeeded him as Minister of Supply, to discuss matters with you if that will be helpful, whenever you are ready.

Hankey, who gave me a great deal of assistance, has kindly promised to join us when we meet.

Handwritten signature
Handwritten initials

Enclosing copies, Nos. 1. and 2.

The Rt. Hon.
Sir Andrew Duncan, G.B.E., M.P.

THE MARK IV (CHURCHILL) TANKMOSTSupplementary Report on Tank
Organisation.SECRET1. PRELIMINARY

1. In a preliminary Report dated 18th December I stated that it would be amplified - without deviation from the main conclusions.

2. This second Report deals mainly with Tank Organisation, both as between the War Office (user) and Ministry of Supply (producer), and inside the Ministry.

II. INTER-DEPARTMENTAL TANK
ORGANISATION

3. There are three levels on which, in theory, tank questions can be dealt with:-

- A. The High Level, namely, the Supply Council, on which the Army Council is represented by the Director-General of Army Requirements (Sir Robert Sinclair). Lieutenant-General Sir Wilfrid Lindsell Service Military Adviser to the Ministry is also a member. At present, however, contact on this level is in abeyance, as the Supply Council never meets.

Whatever the practical effect of this situation, it would, I am sure, create a bad public impression if this were known. People with inside knowledge already criticise the failure of the Council to meet.

- B. The Middle Level, namely the Tank Board, which is the main organ of inter-departmental consultation on tank questions. Its composition and Terms of Reference are attached (Appendix).

The Tank Board satisfies the requirements of the War Office, especially since a recent agreement to widen in practice the scope of the discussions, which had tended to focus on points of detail.

I have something to say below (Section III) about the Chairmanship.

- C. The Low Level of day-to-day contact on questions of detail. This is carried out by two military liaison sections (formerly combined in a single section), one in the Department of Mr. Oliver Lucas, the other in that of Mr. George Usher. For some time following the division into two sections contact with the War Office on this level deteriorated, but now it is reported to be satisfactory. It would be well to change the personnel from time to time in order to ensure that it includes military officers of up-to-date experience in tanks.

*Distribution Copies 142 - Sir Andrew Duncan
3 - Lord Hawley
4 - File*

III. TANK ORGANISATION IN THE MINISTRY OF SUPPLY.

4. Within the Ministry, Tank Organisation gives a lop-sided impression. This is due partly to frequent changes of Minister, each of whom has brought in new Directors, usually without any previous experience of tanks. (See list in Appendix II).

5. On the Tank Board the representatives of the Ministry of Supply quite rightly include the Head of Design (Mr. Lucas) and the Head of Supply (Mr. Usher). The first respect in which the Board appears lop-sided is that Mr. Lucas is the Director-General of all design in the Ministry (including guns, transport, signalling apparatus, etc.), whereas Mr. Usher is the Director General of Tank Production only, and, in the hierarchy of the Ministry, ranks lower than Mr. Lucas.

6. A second point of lop-sidedness is the Chairman, Mr. Burton, who is Director-General of Mechanical Equipment, a post that does not include responsibility for tanks apart from their equipment. Mr. Burton, therefore, notwithstanding some past experience in tanks, is not very well placed to decide questions that may arise between the Directors-General of Design and Tank Supply respectively. Such decisions have, it is understood, been taken, not by the Chairman of the Tank Board, but by Sir William Rootes, the Chairman of the Supply Council, or by the Minister.

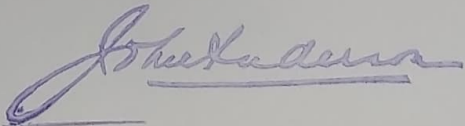
7. The following steps are suggested:-

- (i) To remove tank design from the responsibilities of the Director-General of Design and to create a Director-General of Tank Design on the same level as the Director-General of Tank Supply.
- (ii) To place both these Directors-General under the authority of one of the highest officials of the Ministry in personal touch with the Minister. (That official would then appropriately become the Chairman of the Tank Board.)

IV. FUTURE MARKS OF HEAVY INFANTRY TANK.

8. Evidence tends to show that neither light motor-car manufacturers nor the heavier branches of industry have the right experience for tank development and construction. The tank partakes of both but has peculiarities of its own. The only British firm which has the right kind of experience for design, development and construction of tanks is Vickers, who were responsible for the successful Valentine tank.

9. If, as was understood from Mr. Lucas, the Design Department of the Ministry is to take a share in the design of a possible successor to A.22, it appears worth while to invite Messrs. Vickers simultaneously to design and develop a tank with the same characteristics.



APPENDIX I
TANK BOARD
MEMBERS.

<u>War Office</u>	<u>Ministry of Supply</u>
General Macready	Mr. Oliver Lucas
General Richardson	Mr. George Usher
	General Crawford (as Mr. Usher's Deputy)
Colonel Green (liaison with American authorities)	
Mr. H.H. Burness, Secretary.	

TERMS OF REFERENCE

The following Terms of Reference were communicated to the Tank Board from the Minister on 7th November, 1941.

- (i) To consider General Staff specifications, types and programmes of Armoured Fighting Vehicles, including their armament and equipment and to take decisions thereon.
- (ii) To receive design and production progress reports.
- (iii) To advise the Minister on such questions as he may refer to them.

APPENDIX III.

THE MARK IV (CHURCHILL) TANK.

Preliminary Report.

The Minister of Supply has asked me to give, after enquiry, a personal judgment on the merits and demerits of this tank. I now submit a preliminary report.

I have seen and examined representatives (Major General Macready, A.C.G.S., and Major General Richardson, D.A.F.V.) designated by the Secretary of State for War, representatives of the Ministry of Supply (Mr. Lucas, Controller-General of Research and Development, Mr. Robotham, Chief Engineer for Tank Design, and Colonel Gordon Hall) and representatives of Vauxhall Motors Limited (Messrs. Bartlett, Lasky & Drew). The following conclusions seem to me to emerge clearly:-

1. After Dunkirk it was urgently necessary to produce the greatest possible number of infantry tanks for the defence of this country. In the absence of any approved type, a machine had to be produced according to a broad specification laid down by the military authority, direct from the drawing board. This was an inevitable, if deplorable, necessity.
2. The machine designed and produced by Vauxhall Motors naturally exhibited a large number of initial defects.
3. Despite this, it was decided to produce a maximum number of tanks, relying upon the introduction of improvements according to experience as production proceeded.
4. In the given circumstances this decision was right. Maximum production was a vital necessity. It could be achieved without in any way prejudicing the introduction of necessary improvements as rapidly as accumulated experience rendered possible.

5. It is reasonable to hope that at some date between January and March next, the Mark IV tanks coming out of production will be battle-worthy for all theatres of war. This cannot, however, be established with certainty until the last of the necessary improvements have been incorporated and thoroughly tested. This will be in March next at latest, and possibly in January.
6. It should be possible to re-work 700 out of the 1,000 machines produced in the meantime, and to incorporate all necessary improvements. The remaining 300 cannot profitably be dealt with in this way and should be kept as training machines.
7. Against the possibility - which, as indicated above, cannot be altogether excluded - of the Mark IV machine proving eventually unsatisfactory, the new infantry tank now being designed should be pressed forward and, as soon as a prototype has been thoroughly tested, preparations should be made for replacing the Mark IV tank in production by this new type.
8. The results of the "Bumper Exercise" given in the appendix cannot be regarded as in any way satisfactory. But machines taken out of the production line at a later stage have given such results under test as to warrant the provisional conclusion set out in 5 above.

This preliminary report has been made at the request of the Minister of Supply as a matter of great urgency. It will be amplified - without deviation from the main conclusions - in the course of the next few days.

(Intld.) J.A.

12th December, 1941.

With LORD HANKEY'S compliments.

PAYMASTER GENERAL'S OFFICE,

PRIVY COUNCIL OFFICE,

WHITEHALL, S.W.1.

21st January, 1942.

SECRET.

*Not with
the Tank paper
A 22/1*

I have received the enclosed letter, dated 14th January, from Tennyson d'Eyncourt, Mr. Ricardo, Major-General Sir Ernest Swinton and Sir Albert Stern about their T.O.G.II tank. I have only sent them a bare official acknowledgment, and my inclination was to do nothing more, as I understood from Lord Portal that they had sent a copy to the Ministry. On second thoughts, however, I feel I ought to let you have my views on the subject.

I have no means of substantiating the claims which these gentlemen make in the letter. If, however, they are correct, they would seem to have accomplished something that compares most favourably with any other recent accomplishment in tank design and development.

They claim to have produced a tank of over 70 tons weight, which will carry a 17 pounder gun, and on trials has carried a 3" 20 cwt. A.A. gun - to say nothing of a 6 pounder. If it be true, as claimed, that they have produced an engine, a track, an efficient turret and armour, an infinitely variable speed gear from 0 to 9 m.p.h. with no gear change and with ease of control, as well as a system of suspension that will stand up to these weights, and if, as stated, after running 300 miles at Lincoln, T.O.G.II has now run for 7 days at Farnborough without showing any mechanical defects, there must be some value in their work. At any rate they seem to have accomplished the task that was set them at the beginning of the war by the War Office and the Ministry of Supply.

It may be that the specification for T.O.G.II is now out of date according to modern ideas, but, even if the tank itself is not required, it looks as if some of the component parts ought to be adaptable to other heavy Infantry tanks, and ought to be carefully studied and considered by those responsible for their design.

The Rt. Hon. Lord Beaverbrook.

These

These people worked as a group in the last war, and they are still working as a team. If there is truth in their claims, it would seem a great pity to disband them, as they did produce the tanks that were an element in winning the last war - and the tanks of that day were as heavy as, or heavier than, most of those we are now constructing.

I strongly urge, therefore, that their work shall be considered without prejudice and on its merits.

I need hardly say that the writers of the enclosed letter have no knowledge of the fact that I have written to you, and that my doing so is entirely spontaneous.

This Committee consisted of:-

Sir Albert G. Stern, KBE, CBE, (Chairman).

Sir Eustace d'Ava (Sgd.) HANKEY, CBE, DSO, DSC, FRS.

Major-General Sir Ernest Swinson, KBE, CMG, DSO.

Major H.B. Wilson, CBE.

Mr. H.C. Pound (Naval Construction Dept., Admiralty).

From:

a new and improved type of Barham Court,
with traverses at the base. MAIDSTONE.

a new and improved type of 14th January, 1942.

Sir,

In September, 1939, the Special Vehicle Development Committee was constituted by Mr. Burgin, Minister of Supply, because he and his technical advisers were not satisfied that the development of Tanks at the Ministry at that time would meet the future requirements of warfare. They believed that Tanks of far greater offensive power would be required.

This Committee consisted of:- at the request of the Committee, been assigned for this tank, giving 3000 f.s. val. Sir Albert G. Stern, KBE., CMG., (Chairman). armour plate at Sir Eustace d'Eyncourt, Bart., KCB., LL.D., D.SC., FRS. Major-General Sir Ernest Swinton, KBE., CB., DSO. Major W.G. Wilson, CMG. Mr. E.C. Pound (Naval Construction Dept., Admiralty). Mr. K. Symes, OBE., After sanction by the Tank Board Mr. H.R. Ricardo, FRS., FRAES., MCIME. vetoed by the Mini Colonel Watson, OBE., MC., (liaison officer, later completed by 1st September, 1941. Major Gordon-Hall). factories which were prepared to build it. It would have been an 18

Two experts on electrical and hydraulic transmissions were appointed by the Admiralty.

The C.I.G.S. welcomed this development and on 28th September forwarded a specification for a far more powerful weapon than had hitherto been thought of by the authorities. their services were no longer required. In spite of this, however, they are carrying on with their work.

This Committee has developed the only Diesel electric and hydraulic transmissions for Tanks in this country. fixed to take place before the Tank Board at Farnborough on January 2nd.

It has developed and constructed:

Passes to be present at this demonstration were refused the members of the Committee who were responsible, namely:

a new improved type of track, the depressed track.

a new and improved type of turret on a ball mounting, with traverse at the base.

a new and improved type of tank construction, namely a mild steel skin with the armour bolted on the outside, eliminating expensive machining of the latter.

The tank has infinitely variable speed from 0 to 9 m.p.h., without gear change, and the ease of control is a great feature. (At the trials at Lincoln before General Richardson, D.A.F.V., after he had driven the Tank, his M.T.C. chauffeuse, who had never previously been in a tank, immediately drove it round the ground with consummate ease.)

A 17-pr. high velocity gun has, at the request of the Committee, been designed for this Tank, giving 3000 f.s. velocity with a penetrating power of 150 mm. of armour plate at 500 yards.

The design drawings of a new double deck Diesel engine, with all its auxiliary drives, for tank propulsion have long since been completed. After sanction by the Tank Board, the development of this engine was vetoed by the Ministry authorities. Three prototypes could have been completed by 1st September, 1941, at three different factories which were prepared to build it. It would have been an ideal engine for both heavy and medium tanks.

On 19th November, 1941, in the midst of these developments of the highest importance to this country, all the members of the Committee, with the exception of the Chairman, received notice from the Secretary of the Ministry of Supply that their services were no longer required. In spite of this, however, they are carrying on with their work.

The official trial of the S.V.D.C. tank, viz TOG 2, was fixed to take place before the Tank Board at Farnborough on January 2nd.

Passes to be present at this demonstration were refused the members of the Committee who were responsible, namely:

Sir

Sir Eustace d'Eyncourt
Sir Ernest Swinton
Mr. H.R. Ricardo

and Sir William Tritton. It was only after most cogent representations had been made to Sir William Rootes personally that invitations were sent.

We understand on good authority that the Army in Egypt is now crying out for the mounting on tanks of a high velocity gun of larger calibre than is at present carried by the enemy tanks.

The present Tank Board has not yet produced a standard Tank in battle mounting even a 6-pr.

T.O.G.2 is designed to carry the new 17-pr. gun. (On its trials it carried the only heavy H.V. piece available, viz the 3" 20-cwt. A.A. gun.)

After running 300 miles at Lincoln, T.O.G.2 has now run for seven days at Farnborough without showing any mechanical defects. The experimental authorities at Farnborough have so far expressed their satisfaction with the performance of the machine.

T.O.G.2 is the only tank in existence designed to carry a 17-pr. gun which could be produced in numbers in this country within 12 months. Considerable quantities could be produced within the year. No other tank to carry a 17-pr. could be designed and produced in quantity within two years in this country.

T.O.G.2 has in all its parts been specially designed with a view to simplicity and ease of manufacture.

It has been intimated to Sir Albert Stern by Sir William Rootes and Mr. Lucas that he should relinquish his post in the Ministry of Supply, but he has refused to resign from his labours, which are of such vital national importance. His Committee and staff are in full agreement with him, and decline to hand over the fruit of their labours, to which they have devoted so much time, to those absolutely without experience in the development of the heavy tank.

The Committee have to some extent succeeded in repairing twenty years' loss of time in the development of mechanical warfare (1919-1939) in this country, but regard this development as being still in its infancy, and have already in hand a much improved machine of the T.O.G. type.

In their opinion, it would be absolutely disastrous to interfere at this time with their basic research work in diesel engines, electric and hydraulic transmissions, track suspensions, turrets, armour plate and other novel features necessary for the successful design and production of heavy tanks.

We are, Sir,

Your obedient Servants,

(Sgd.) E.H.T.d'Eyncourt

Harry R. Ricardo.

E.D. Swinton

Albert Stern.

The Lord Hankey, GCB., GCMG., GVO.,
Privy Council Office,
Whitehall, S.W.1.

The Rt. Hon. Sir John Anderson.

SECRET.

TANKS.

I had a short interview with two people connected with the T.O.G. tank to-day. The first, Mr. Inglis, is the head of an important department of Merz and MacLellan who have produced what is claimed to be a successful electric transmission for the 67-ton tank known as T.O.G.II produced by Sir Albert Stern's Group. He was sent to me by Mr. Beard a member of the Engineering Advisory Committee and a partner of Merz and MacLellan. Mr. Inglis stated that he was at present attached to the Design Department at Farnborough where he is doing some work on tank turrets and he had seen a gooddeal of all our tanks.

He thought that the root mistake in the Churchill tank had been in handing over the development to a firm of light motor manufacturers. He paid a tribute to the Vauxhall Company and General Motors, but said that no firm of light motor manufacturers could possibly tackle the problem of tanks. He himself had learnt a good deal about tank construction in the last two years, and he was convinced that it required very specialised knowledge such as was not possessed either by the heavy or the light engineering industry. It required a combination of the two. The only firm in the country that possessed this knowledge was Vickers who had been constructing tanks for years and years. It was Vickers who had produced the Valentine tank which was the only really completely successful tank, though now the Crusader was a fairly good tank. He found it difficult to believe that a really good job could be made of the Churchill tank, which in his opinion was of faulty design.

One interesting statement he made was that to the best of his knowledge Mr. Robotham was handing over the development of the successor to the Churchill tank to Rolls Royce. Derby, he said, was to become the great centre of tank development construction and trial in this country. He did not think that this was right. Granting that Rolls Royce were the finest motor engineers in this country, he insisted that they had not the specialised knowledge of tanks which was essential and which he had said earlier was possessed only by Vickers. He was convinced that the only result of this latest move was that there would be another long delay while Rolls Royce were so to speak buying their experience.

Referring

working members of Stern's Committee which has produced the tank. As I have not heard Rootes' side I pass on comment.

Referring to T.O.G.II he had only been concerned in the electrical transmission, and this had come out satisfactorily although if he could start again he could raise the speed of this monster tank, he thought, from 7 miles to 12 miles an hour. He added that T.O.G.II was now being subjected to full tests at Farnborough, including a thousand miles trial and so far to the best of his knowledge had done pretty well.

The above interview took place at 12.45 p.m.

The second interview, which was a very short one, took place at 3.15 p.m. and was with a Mr. Gwynne whom I had been earnestly begged to see by Lord Motistone who had only mentioned that it was connected with tanks.

Mr. Gwynne told me that he was a Director of Fosters of Lincoln who had been concerned with the development of the T.O.G.II tank of Sir Albert Stern's Group. He was brief and to the point, and began by handing me the attached private and personal memorandum.

Mr. Gwynne explained that he was not so much concerned to speak of the T.O.G.II tank as of tank development generally. From the memorandum it will be seen that he is dissatisfied with the present organisation, and suggests an alternative organisation which seems to be devised on sound lines. I did not extract any additional information on this aspect beyond what is in the memorandum. As a matter of fact Mr. Gwynne's proposals do not differ so very far from the present arrangement except as to the Chairman of the Tank Board.

Mr. Gwynne's grievance is that Rootes refused permission to Eustace d'Eyncourt, Ricardo and Swinton to be present at a trial of T.O.G.II at Farnborough experimental ground on January 2nd, which at first sight appears to be rather an unnecessary exclusion as they have all been

working

working members of Stern's Committee which has produced the tank. As I have not heard Rootes' side I pass no comment.

Since the war started there have been four Ministers of Supply and quite a number of them. The latter have all failed to produce the very considerable length of time, and those who have done so have not been a knowledge of Tank design, development and production. In one case the person appointed as Director of design had never seen a Tank until after his appointment.

We feel that the success or otherwise of specialized effort required depends greatly on the individuals at the top and consequently we venture to suggest that a Tank Board should consist of four people as follows:

1. A Chairman who should have the full confidence of the War Cabinet, and with political, military and business experience. Above all, he must be willing to give his whole time to this work.

2. A member of the General Staff who should be in a Paymaster General's Office, what argument it is essential is Privy Council Office, effective armour should be Whitehall, S.W.1. to give general views from the

6th January, 1942.

COPY

PRIVATE & PERSONAL.

We feel with considerable concern the apparent lack of co-ordination and direction in the national effort to produce tanks. Our contact with the problem due to the work we have been doing for the S.V.D.C. has brought us certain experiences which lead us to the view expressed below. Here let us say that our Heavy Tank T.O.G. is not the main object of this note, as we realise that our activities form a very small proportion of the Tank effort.

Since the war started there have been four Ministers of Supply and quite a number of Tank Boards. The latter have all failed to function for any reasonable length of time, and their basis of selection has not been a knowledge of Tank design, development and production. In one case the person appointed as Director of Design had never seen a Tank until after his appointment. (And Committee).

We feel that the success or otherwise of specialised effort required depends greatly on the individual at the top and consequently we venture to suggest that a Tank Board should consist of four people only:-

1. A Chairman who should have the full confidence of the War Cabinet, and with political, military and business experience. Above all, he must be willing to give his whole time to this work.
2. A member of the General Staff who should be in a position to say what armament it is essential to carry and what protective armour should be provided, and to give general views from user's standpoint.
3. A Director of Design and Development work who need not necessarily be an engineer, but a person familiar with the subject and in a position to call together experts and technicians and co-ordinate their efforts. This position also should be a full-time job.

4. A Director of Production with experience of mass production to take the complete design after the experimental work has been done and the machine is approved, and see that it is made under the most expeditious conditions.

It should be within the power of the Director of Design and the Director of Production to appoint such technical committees as they require.

Typically, we might suggest a Board made up as follows:-

CHAIRMAN.

(A man with Cabinet support).

Armour & Armament.
(And Committee).

Design.
(And Committee)

Production.
(And Committee).

Above all, we would like to stress that this should be a full-time job with an assurance of continuity. The importance of the Director of Design and Development being entirely independent of the Director of Production, except through the Chairman, is well illustrated in our own case.

We, at Fosters, have been occupied with the development of a Heavy Tank, twice as heavy as any known Tank, under instructions from the S.V.D.C. The development of this tank has introduced many novel problems in tank design, some of which may be set out as follows:-

(1)

The transmission for such a heavy machine required special consideration and in the early stages it was decided that it would be very improbable that a satisfactory mechanical gear-change could be produced. Further, the possibility of obtaining gearing seemed to be doubtful. It was therefore decided to incorporate electrical transmission and this decision was to some extent confirmed by a visit to France, where we found that the French had projects for

heavy Tanks, all of which embodied electrical transmission. Quite recently we have learned that the Americans are also developing electrical transmission for heavy Tanks.

The design of the electrical transmission was placed in the hands of the English Electric Company who have, after several failures, produced what appears to be a sound and suitable transmission which is easily operated and fool-proof. It suffers, however, from the disadvantage of large bulk and weight, common to all electrical transmissions.

We are also developing a hydraulic transmission but this has not yet been tested.

(2)

The armouring of such a vehicle was carefully considered and it was decided to build a mild steel shell and on this fix the protective armour, in the form of flat plates which, we understand, are easier to obtain and offer better protection than cast armour.

(3)

The armament for such a vehicle has never received the thought that should have been given to it by the Military Authorities and has gone through stages of 2-pdr., 6-pdr., 3" A.A., and now stands at 3", 17-cwt. gun.

(4)

The suspension of the vehicle has necessitated careful attention and the development of a sprung suspension is now receiving close attention.

(5)

Track rollers of various types have been developed and so far our experiments show that rubber rollers are not suitable for the very heavy loads imposed upon them.

It is very important to appreciate its position in the fighting scheme, for it is not possible for it to be a universal weapon. Just as in the Navy it is found desirable to have many types of ship to cover the duties required, and so there are produced heavy Battleships, Cruisers, Destroyers and very fast light craft. So our Tank called T.O.G. is a "heavy" and the speed due to size and armour is slow compared with other craft. It is still fast enough to lead the Infantry and protected against heavy field guns.

So many of our visitors have the idea that nothing is any good that will not fly round at absurd speeds.

Another point we make is that we think we have evolved a method of driving that enables its great weight due to the large gun and heavy protective armour to be handled with ease, is foolproof, and can be driven at once by anyone - requiring only a minute or two's teaching.

In conclusion, and as an example of where the lack of co-ordination in tank design has led us, we would point out that the country has at present three Infantry Tanks:

1. Mark III (Valentine) weighing 16 tons, having a speed of 16 m.p.h., carrying a 2-pdr. gun in the turret.
2. Mark II (Matilda) weighing 25 tons, having a speed of 15 m.p.h., carrying a 2-pdr. gun in a slightly larger turret.
3. Mark IV (Churchill, a most unfortunate christening) weighing 38 tons, having a speed of 17 m.p.h., carrying a 2-pdr. gun in practically the same turret as the A.12. Recently some efforts have been made to carry a 6-pdr. gun on this machine, but we have no knowledge of the results.

Anyway, as designed, you have three machines, all approximately the same speed, with approximately the same armour and the same armament, but one weighs 16 tons and the latest weighs 38 tons. As far as reliability is concerned the 16-ton machine is far superior to the 38-ton machine, so we have 22 tons being carried about for no useful purpose.

29th December, 1941.

Dear Mr. Rootes,

I understand that T.O.G.II is to be given a trial at Farnborough Experimental Ground on January the 2nd at, or soon after, 12.30 p.m. and that you and Lord Portal will be present, also the members of the Tank Board.

At the special request of the Minister of Supply in 1939, the special Vehicle Development Committee, of which I am Chairman, undertook to try to design and build a heavy tank to carry a high velocity gun. I understand from my talk with you on the telephone on Friday last, that the other members of this Committee are not to be allowed to be present on this occasion. This seems inexplicable to me.

The three members who you wish to exclude, and who are also responsible for the production of this weapon, are all distinguished tank men: Sir Eustace d'Eyncourt, D.Sc., technical expert on tanks, Mr. H. Ricardo, diesel engine expert, especially as regards tanks, both Fellows of All Souls, Oxford, late Professor of Military History and expert on Tank strategy and tactics. Further, you wish also to exclude the technical adviser to this Committee, Sir William Tritton, whose knowledge of heavy tractors and tanks is recognised throughout the world.

As far as these men are concerned, it cannot be a question of secrecy. Naturally, they know of the trial on January 2nd, but do not yet know that they are to be excluded by your orders. You stated on the telephone that I had agreed that only the Tank Board should be invited to see T.O.G.II on this occasion. That was not a question for me, but one solely for the Minister of Supply to decide. I did not, however, dream that the members of the special Vehicle Development Committee were to be excluded, or I should have made a most solemn protest, which I now do. I trust you will see your way to extending invitations to the above.

Yours sincerely,

(Sgd.) ALBERT G. STERN.

W. Rootes, Esq.,
Shell Mex House.

SECRET.

MISC. (41) 22/3rd Meeting.

COPY NO. _____

WAR CABINET.

THE CHURCHILL TANK.

DRAFT MINUTES of a Meeting held in the Lord
President's Room at 3.30 p.m. on the 11th
December, 1941.

PRESENT:

The Rt. Hon. Sir John Anderson, M.P.,
Lord President of the Council, (In the Chair).

The Rt. Hon. Lord Hankey,
Paymaster-General.

Mr. C.J. Bartlett,	Managing Director	} Vauxhall Motors Ltd.
Mr. A.W. Laskey,	Assistant Managing Director	
Mr. H. Drew,	Assistant Chief Engineer	

Secretary.....Mr. H. Everett.

THE CHURCHILL TANK.

THE CHAIRMAN explained briefly why he was concerned in the matter, that he had seen the papers relating to this tank and had interviewed representatives of the General Staff and of the Ministry of Supply, and that at Lord Beaverbrook's suggestion he had asked the representatives of Vauxhall Motors Ltd., to give him their side of the question. Any report that might result from the enquiries would be confidential and would be sent in the first place to the Minister of Supply.

MESSRS. BARTLETT, LASKEY AND DREW made statements in reply the effect of which was as follows:-

1. THE GENERAL CIRCUMSTANCES IN WHICH THE TANK A.22 WAS PRODUCED.

- (1) The A.22 was often regarded as the direct descendant of the Tank A.20 manufactured by Messrs. Harland and Wolf, but this was hardly an accurate picture since A.20 had been a purely experimental

(14) machine, to be powered by a Meadow's engine which was not, in fact in production, and with a hand made gear box and other components. No A.20 components were built into A.22 since none were available.

(ii) In March 1940, Vauxhalls were informed by the Ministry of Supply that there were then no specialised engines available for tanks, and they agreed as a matter of extreme urgency to manufacture an engine for A.20. They succeeded in doing so in three months, but owing to the rush it was quite certain that there would be trouble with this engine.

(iii) In July 1940 Vauxhalls were suddenly informed that arrangements which had been made for them to manufacture a light Hotchkiss Tank had been cancelled and they were asked to produce the tank known as A.22. They received messages from the P.M. and the Minister of Supply, and from General Crawford and other representatives of the Mechanisation Board. They were given very broad specifications, e.g., the crew to be three men in the turret and two others) and were urged if possible to produce the tank in twelve months. It was stressed that there was great fear of invasion and that for the purpose of resisting an invasion the work must be rushed through as soon as possible. The General Staff needed all the A.22 tanks that could possibly be made in the twelve months for home defence, and they would be acceptable if they could run only 50 miles, or even only 10 miles. Vauxhalls had no

but no other firm in the country had experience of making a tank of this type. An order was placed for at least a thousand and it was stressed that if possible 500 should be delivered for home defence within the twelve months.

(iv) In view of the urgency it was agreed to put^{it} into production nearly straight from the Drawing board: there was no time to manufacture and test a prototype if delivery was to start within twelve months.

(1) It was clear to all the technical experts both at Vauxhalls and at the Ministry of Supply that this course would inevitably lead to trouble.

(v) Relations between Vauxhalls and the Design Department of the Ministry of Supply had always been excellent. When the production of A.22 was decided on, the matter concerned the Mechanisation Board. Later the Board ceased to exist and was succeeded first by the Directorate of Tank Design, and then by the Department of Tank Design. Dr. Merritt from the small scale Design Department at Staines came to Luton with a staff to help Vauxhalls, chiefly with the fighting side of the tank, but also partly on the mechanical side. The chequered career of the Design Department, with its many changes in personnel made the collecting of experiments very difficult. Unfortunately the Army had no Central Engineering Department and appeared to have no adequate records of past experience with tanks. In war time a collection of engineers could be rapidly improvised, but not a satisfactory team. It would be possible during a period of peace, and given sufficient time and money to build up a Government Design Department adequately staffed with highly expert engineers, but if a design was suddenly needed in war-time it was necessary to go to an outside firm possessing a comprehensive organisation.

(vi) It was impressed on Vauxhalls that in arranging

(144) for the manufacture of A.22 they must not place out any work with firms already occupied on the manufacture of other types of tanks.

2. THE PRODUCTION OF A.22.

(i) Since July, 1941, A.22 had been coming off the production line and simultaneously work has gone on improving the design and correcting the faults. Owing to the complexity of the machine, and its manufacture by a large number of subcontractors it took three to four months to put through any substantial alteration to the production model. Very considerable progress had been made in improvements and owing to the time factor it had not always been possible to explain the detailed improvements to the Ministry of Supply. Vauxhalls had never sought authority from the Ministry of Supply before making improvements. Improvements had been directed partly to the design, partly to the materials used and partly to the manufacturing methods.

(ii) The tanks then coming off the assembly line gave comparatively little trouble. Last week two of them after they had passed the inspection department of the Ministry of Supply were loaded with guns, equipment and crews and sent round a 65 mile concrete road circuit. Their average speed was 14 m.p.h., top gear being used. After the first day the crews checked over the tanks and next day the circuits was repeated. No trouble was experienced other than two trivial faults which did not affect the running of the tanks. Petrol consumption was at the rate of 0.85 miles per gallon, which would give the Tank a greater range than had been asked for in the specification.

- (iii) A simultaneous trial has been carried out with another specimen equipped with certain further improvements such as rubber tyred wheels. This did 500 miles in 14 days and had then done nearly 700 miles without any serious trouble.

3. PARTICULAR ASPECTS OF A.22.

- (i) The engine gave some 360 h.p. and was sufficiently powerful for its purpose. It would be an advantage to have some power in hand if it could be secured without an increase in weight, or engine space, but this was not regarded as possible. The weight of the tank was such that it could not travel at 20 m.p.h. even if the engine would drive it at such a speed. When the engine was first put into the tank, where it was necessarily closely shut in, it gave trouble of a kind it had never given on the bench. These troubles had chiefly been overcome.
- (ii) The gear box at present gave the most trouble. It suffered from no radical defect, but from a collection of separate minor troubles. It had been designed especially for the tank, largely by the firm of David Brown and Sons, Huddersfield, who had previously specialised in hand-made gear boxes of unusual design, not in mass production.
- (iii) The suspension had given considerable trouble, but was then regarded as cured within the fundamental limits of the design. At first trouble had been caused by loss of oil in the bogey wheels and by bad quality cast wheels. The loss of oil had been cured and forged wheels had been substituted for the castings. The stroke in the suspension provided for a three inch rise and a two inch fall, with a very powerful spring in the last three quarters of an inch each way.

A longer stroke would involve considerable changes in design and some increase in height.

(iv) The specifications allowed for a maximum differential in the temperature between the air inside and outside the tank. This figure had now been achieved, but Vauxhalls hoped to provide a larger margin of safety which would fit in better to operate in a hot climate, such as Libya. It was doubtful whether any tank or tank crew could operate in a temperature such as that of Mesopotamia in summer with a temperature of 120° to 125° F. in the shade. A.22 could be started at Zero Fahrenheit, but it was not clear how in Russia tanks were started when the temperature was well below zero.

(v) The tracks had given trouble but were now much improved. Vauxhalls made three experimental patterns and concentrated on the best, increasing its life from 100 miles to 2000 miles.

4. MR. BARLETT'S FINAL VIEWS WERE AS FOLLOWS:-

(i) By the latter part of January, 1942, the tanks coming off the production line would be battle-worthy or nearly so. Even then almost unending refinements or functional improvements could continue to be made.

(ii) He was strongly of the opinion that a battle-worthy tank could not have been produced in a shorter time, even if there had been less insistence on maximum production. It inevitably took time to incorporate improvements into the production line. Improvements had been incorporated at the earliest possible moment.

(iii) Some of the troubles with A.22 had been increased by the fact that the crews were largely untrained.

The Vauxhall representatives were thanked by the Chairman and withdrew and the Chairman and Lord Hankey discussed the results of the three meetings, and considered a paper prepared by Lord Hankey on the basis of the documents and of the first two meetings.

After some discussion it was agreed, that their broad conclusions should be as follows:-

- (i) It was deplorable that it had been necessary to produce an infantry tank in the summer of 1940 as a matter of extreme urgency and without a pilot model.
- (ii) In the circumstances the decision to concentrate on maximum production of A.22 had been correct.
- (iii) There appeared to be good reason to hope that early in 1942, A.22's from the production line would be battle-worthy tanks.

[Lord Hankey was inclined to consider this conclusion somewhat optimistic, but the Chairman pointed out that both Mr. Lucas and Mr. Bartlett were agreed on this point, and that certainty in the matter was impossible until the tanks had been tested by the users.]

- (iv) The Tank Design Department of the Ministry of Supply should be encouraged to push on with their plans for a new infantry tank, both in case A.22 never became a satisfactory battle-worthy tank, and in order to provide a more modern successor to A.22.

- (v) A senior Tank Liaison Officer should be attached to the Ministry of Supply to keep in close contact with the users of tanks both in this country and abroad.

SECRET.

MISC. (41) 22/2nd Meeting.

COPY NO. _____

WAR CABINET

THE CHURCHILL TANK.

DRAFT MINUTES of a Meeting held in
the Lord President's Room at 5.30 p.m.
on 9TH DECEMBER, 1941.

P R E S E N T:

The Rt. Hon. Sir John Anderson, M.P.
Lord President of the Council
(In the Chair).

The Rt. Hon. Lord Hankey.
Paymaster-General.

Mr. Oliver Lucas,
Controller-General of
Research and Development,
Ministry of Supply.

Mr. W. A. Robotham,
Chief Engineer for Tank
Design, Ministry of Supply.

Lt. Col. B. Gordon Hall,
Ministry of Supply.

Mr. H. Everett Secretary.

THE CHAIRMAN explained that there had been private expert criticism of our tank design and production and that there seemed to be danger of something like a public scandal in the matter. It had accordingly been agreed that he should look into the matter by means of secret and confidential enquiries, the results of which would be passed to Lord Beaverbrook and possibly to the Prime Minister. He had seen representatives of the General Staff and had read papers furnished by the Ministry of Supply.

MR. LUCAS made a statement in reply, the effect of which was as follows:-

1. GENERAL POSITION.

(1) The pre-war policy had been to rely on existing commercial engines (such as bus engines) for our tanks and not to design special engines for the purpose, for fear that the expansion necessary for war could not be met if it involved manufacturing large numbers of special engines. In his opinion this policy had proved a great mistake.

(ii) The organization for tank design was based on a Design Department at Egham and a trial ground at Farnborough.

(iii) The policy adopted until recently had been to employ industry extensively for the design of tanks. The staff put in functional specifications of the kind of tank they required, a selected parent firm took on the work and prepared the design with some guidance from the Tank Design Department, particularly on such general features as track pressure, horse power per ton weight, etc.

2. THE CHURCHILL TANK MARK IV.

(i) This tank had been conceived in an unusual way and as an emergency short cut. The specification was contained in a document of 13.10.39 prepared by the Assistant Chief of the Imperial General Staff in which he had enquired whether a pilot model was necessary. The President of the Mechanisation Board in reply had expressed the view that a pilot model could be dispensed with and that this course would involve no great risk, as all the main features in the tank had been tried. Although a tank known as A.20 had been produced by Messrs. Harland and Wolff, the parent designers selected for the Mark IV were the Vauxhall Motor Company who had stipulated that they should secure a considerable degree of freedom in the matter. The firm had no previous experience in the manufacture of tanks.

At that time with the fear of immediate invasion, the Staff were anxious to secure tanks of any performance, however low. If the tanks could only do ten miles it was considered that the Railways could get them near to the points where they would be required, and that if necessary they could be used as immobile pillboxes.

(ii) In his view the production of the Mark IV had been a disaster which had followed inevitably from the absence of a pilot model and from the frame of mind in which the work had been undertaken. As produced the first thousand tanks could not be sent into battle in this country or abroad.

(iii) When he first was concerned in the matter in July, 1941, he pressed the view that production should not exceed the planned rate because of the very considerable teething troubles which called for substantial re-designing, and he urged that stress should be laid on the need for reliability rather than on maximum output. The Minister of Supply decided that they would go right ahead on production of the Mark IV, and as many as possible had been produced since that date. Present production was about 40 a week and the planned maximum was some 180 a month. Vauxhall's were the parent firm, twelve firms were employed in erecting the tank, and a large number of other firms manufactured component parts.

(iv) The showing of the Mark IV in the recent bumper exercises had been deplorable as could be seen from the figures obtained from General Martell's Department on 16.10.41 (Annex).

(1) Mr. Jones had at first wished machines to be placed on the Mark III Vehicle, a small mechanical job likely to be satisfactory for some years, rather than on the Mark IV.

(v) Steady and continuous efforts had been made to overcome the faults in the design, the chief of which were the cooling arrangements for the engine the suspension and the transmission.

(vi) As a result of improvements made, two Mark IV's taken from the production line had run for sixty miles on the road for ~~the~~ two consecutive days without any trouble. Road running tests were particularly hard on the Mark IV in view of its weight and the design of its suspension, which provided for a clearance of only five inches: the whole mass travelled up and down according to the irregularities of the road. An alternative preferable system was for the suspension to have a long enough stroke to take up road irregularities.

(vii) When corrected, the Mark IV ~~could~~ be a useful fighting machine and correction to those coming from the production line should be complete in general by March, 1942. It was hoped that some fifty of the thousand expected to be produced ^{before that date} would be modified by hand by January, 1942. It was proposed that two of the assembly companies should concentrate on the work of manufacturing the components needed to bring 700 of the first thousand up to battle worthy condition by March. It would not probably be possible to modify the first 300 manufactured, which could be used for training purposes; their constant mechanical breakdowns would give the maintenance crews good practice.

(viii) Slowing the production line would not have hastened production of new parts.

(ix) The workmanship of certain of the component parts had not been up to standard, but this had been a negligible factor in the tank's unreliability. It had been necessary to give up the use of top gear, not so much because of gear-box deficiencies as because the transmission and suspension as a whole could not stand full speed. The engine had been specially designed for this tank and, except for its cooling, had proved to be the least unsatisfactory part of the tank. It was of approximately 350 h.p. which was just adequate but provided no margin for increased weight.

(x) He agreed that experience with the Mark IV had shown up all its major defects, but ~~xxxxxxxxxxxx~~ the cure for one defect in the cooling arrangements (not included in Section B of the Annex to the Minutes of the first meeting) had not yet been accepted by the Vauxhall Motor Company. It was difficult to say positively whether the cures for known troubles had been discovered until the cures had been put into practice and tested.

3. The spare part position had undoubtedly been difficult but had recently improved rapidly. It was suggested that certain shortages might now be due to the Army methods of distribution of spares between a Central Depot and Branch Depots. There had been a tendency to run the production of spares too fine in order to push up the production of new tanks. A further difficulty was that until the design of the Mark IV had become reasonably stabilised it was hardly possible to produce useful spare parts.

4. Other points raised in discussion were as follows:-

(1) Mr. Lucas had at first wished emphasis to be placed on the Mark III Valentine Tank, a sound mechanical job likely to be satisfactory for some years, rather than on the Mark IV.

(ii) It was not clear why firms with experience in the manufacture of tanks such as Foster's of Lincoln and Vickers, had not been used more in the earlier part of the war.

(iii) In some instances the General Staff specifications were not very practical and this had been true of the Mark IV.

(iv) The terms of reference of the Tank Board had recently been altered so as to make it clear that matters of design were for the Ministry of Supply.

(v) The User Committee of the War Office interested itself in proto-types, but had not been very active recently, no proto-types having been brought forward.

(vi) For the future a soldier was to be in charge of the fighting properties of new tanks and the trials at Farnborough were to be under a Brigadier who had recently been in Command of a Brigade and had been proposed by the War Office.

(vii) It was not possible to reproduce artificially Russian winter conditions in this country. A tank could be placed in a room at a temperature 40° below zero F. but this temperature could not be maintained after the engine had been running for any length of time.

(viii) Valentine and Matilda tanks had been sent to Russia. The Matilda was not too satisfactory for work in marshes or crossing trenches, but the Mark IV which might also have to be sent had a longer track base and a greater belly clearance. It has proved difficult to secure particulars of the performance of our tanks from the Russians.

(ix) Two advanced models of the Mark IV ahead of the present conditions on the production line had been sent to the Middle East for test accompanied by two of the Vauxhall engineers.

5. A NEW MODEL TANK TO TAKE THE PLACE OF THE MARK IV.

Active steps had been taken to prepare the design for a new infantry tank and to avoid the mistakes made in connection with the Mark IV. The basis of the new design was the Rolls Merlin Engine, a well tried and first rate machine which in its aeroplane form produced approximately 1,500 h.p. nearly twice the 630 h.p. considered desirable for the new tank. The size of the Merlin fitted in well with tank design and considerable research work had been done on problems in connection with its cooling. Models and tests of fans had been made and as a result of research it had proved possible to cool the 630 h.p. engine with the expenditure of less fan power than required for the Mark IV with its 350 h.p. engine.

It was proposed that the Design Department should take more responsibility for the new tank. It was hoped to produce a rationalised basic tank design which could be adapted to different weights of armour by means of different gear ratios. The suspension of the new tank would have a clearance or stroke of 18 inches which should take up the road shocks. It was proposed to embody a number of components from the Mark IV

in order to save time. The new tank would not be put into production until a model has been produced which had passed searching tests. This was the quickest way to produce a tank fit to face the enemy. The weight of the new tank might be beyond the railway maximum, if so it would have to travel under its own power or on carriers from the U.S.A.

No estimate was given of the date on which the new tank would go into production, but a model was brought in and explained to the meeting.

THE CHAIRMAN and LORD HANKEY agreed with Mr. Lucas the names of the most suitable representatives of Vauxhall Motors Ltd., with whom to discuss the question at the next meeting.

Great George Street, S.W.1.

10th December, 1941.

ANNEX.

Tank Casualties in Bumper Operation.

		<u>Number used</u>	<u>Average Miles</u>	<u>Casualties at Zero Hour</u>	<u>Casualties after 48 hours.</u>
Mark III	I	591	250	80	21
Mark V	C	269	300	48	17
Mark II	I	133	200	42	14
Mark IV	I	54	150	40	11

QUESTIONS TO THE MINISTRY OF SUPPLY.

1. How many Infantry Mark IV tanks are on order. With what firms are the orders placed? Does the rate of production tend to vary between different firms?
2. What is the present information of the Ministry of Supply as to the performance of the Mark IV tank, especially from the point of view of mechanical reliability?
3. To what extent have the major defects been overcome, e.g. suspension (described in the papers as "the outstanding problem"), cooling system, engine, gear-box, steering brakes, tracks, petrol system, electrical equipment, mudguards? Has the 1,000 mile test referred to in the papers yet taken place, and if so, with what results?
4. Is it anticipated that when the modifications have been completed the tank will be a really efficient fighting machine, or do the experts of the Ministry of Supply still adhere to the following minute from D.D.G./T.D. dated 6th September:-

"It can safely be said that, although nothing is impossible, the prospect of making this vehicle reasonably reliable at the speed originally specified is sufficiently remote to place it in the category of the practically unattainable"....."There is little justification for assuming that this vehicle could be put into service in a reasonably reliable form without devoting at least another year to intensive development and testing":

and the following:-

"At least a year is required to produce a vehicle having a standard of life and reliability equal probably to the less satisfactory fighting vehicles at present in service".

5. How long are the modifications now envisaged expected to take? What proportion of them is being included in tanks now coming off the line? Is it intended to make these modifications in the tanks that have already been delivered?
6. Do the experts of the Ministry of Supply consider these tanks fit for service in Russia?
7. When are the conveyors for the tanks expected to arrive from America? Is this likely to be interfered with by the American intervention in the war?
8. Has the Ministry of Supply accepted the War Office demand for spare parts? If so, what measures are being taken in the matter? If not, why not?.

9. Why was Vauxhall's selected as the parent company for A.22? Is it not a fact that the firm was wholly lacking in experience of tanks and even of the heavy motor industry? Why were Harland and Wolff thrown overboard when A.22 took the place of A.20? Why was no use made of firms which had constructed or developed tanks like Vickers or Messrs. William Foster & Co., of Lincoln, or other firms employed in the last war? Was any use made of Consulting Engineers, either for the tank or its engine? Why was no use made of Mr. Ricardo, who designed the standard engine for tank work in the last war (Official History, page 43), and is now engaged mainly on aircraft engines?

10. What are the plans of the Ministry of Supply for the future of the Infantry Tank Mark IV? What is being done to design and develop a new pattern tank of the same class? Have the War Office given the Ministry a specification, and has that specification been discussed with representatives of the War Office, the Tank Corps, and with manufacturers?

11. Does the Ministry of Supply consider it

would be useful to attach to Farnborough a senior liaison officer of the Tank Corps, whose function would be to place at the disposal of Farnborough the fullest possible information of the user?

12. In the Ministry of Supply papers (Appendix II) reference is made to a Tank Board Sub-Committee of Investigation. Would that Report be useful to the Lord President?

9th December, 1941.

HISTORY OF A.22.

1. Infantry Tank Mark IV (A.22) was based on an earlier model designed for use on the continent of Europe and known as A.20. In that case it was decided to dispense with the pilot model stage of development, but a pilot model actually ran in May 1940. After the collapse of France A.20 was replaced by A.22, which was designed mainly for Home Defence on a new War Office specification. It was once more decided to go into production without awaiting the pilot model stage of development. In November, 1940, however, the Design Department began to draw attention to the risk of a long development period, and, after the production of a pilot model in May 1941, the Department repeatedly urged a curtailment or even a cessation of production until an efficient fighting machine was produced. In view, however, of the urgent need for a large Infantry Tank for Home Defence, a decision was taken on the highest level to continue production without awaiting trials of the pilot model or the introduction of modifications.

PRESENT VALUE

2. A.22 is a well armoured tank. At present the armament is too light for modern conditions, but in February 1942 and thereafter a 6-pounder gun in a turret will be carried. The present model, however, is unreliable from a mechanical point of view, and cannot at present be described as war worthy or fit for use in a hot climate owing to cooling difficulties. It is hoped, however, that this particular objection may not exclude its use in Russia. The mechanical unreliability is illustrated by its performance at the Bumper Exercises in September - October. The 54 Infantry Mark IV Tanks employed ran an average of 150 miles in the four days in easy country, fine weather and mostly over roads. At the end of the Exercises 40 were casualties. 48 hours later, however, only 11 remained as casualties.

VALUE AFTER MODIFICATIONS.

3. The Ministry of Supply have obtained from the parent firm (Messrs. Vauxhall Motors) a complete list of defects and are taking energetic steps to correct them. Some of the minor troubles, as well as "teething troubles" have already been overcome. The Ministry of Supply believe that the principal defects can be surmounted by change in design. The War Office

accept this view. Until March 1942 the tanks produced will be mainly of the present type, subject to such minor modifications as can be introduced before then. It is hoped that some 50 of the 1,000 expected to be produced before that date will be modified by hand by January 1942. In March the Ministry of Supply hope that battle worthy tanks fit to operate in any country will be in production. There is, however, always a risk that new defects may develop. In addition the Ministry of Supply propose that two of the Assembly Companies should concentrate on the work of manufacturing the components needed to bring 700 of the first 1,000 tanks up to battle worthy condition by March. The first 300 manufactured cannot be modified and will be used for training.

PROVISION OF AN IMPROVED INFANTRY TANK.

4. The Ministry of Supply has in hand arrangements to produce a rationalised basic tank design which could be adopted to different weights of armour and armament by means of different gear ratios. Their plan also envisages standardisation of parts as far as practicable so as to reduce the need for re-tooling. Steps have also been taken to prepare the design for a new Infantry Tank of the same class as the Mark IV, and to avoid the mistakes made in connection with that tank. The new tank will not be put into production until a model has been produced and has passed searching tests. The War Office are anxious that the design and development of the new tank should proceed parallel to the continued manufacture of the modified Mark IV tank. In view of the possibility that the modifications now being made might not result in a satisfactory tank, this is most desirable. A new tank however will take at least 18 months to develop.

SPARE PARTS.

5. The War Office report that the spare parts position is very bad for all types of tanks, including the Mark IV Infantry Tank. The Ministry of Supply admit that the position has not been satisfactory but claim that it is improving, and that they are doing their best to put matters right. The production of spare parts presents technical difficulties, especially in the case of a tank like the Infantry Tank Mark IV which has not reached its final development.

TANK CARRIERS.

6. Some tank carriers capable of carrying weights up to 40 tons and towed on the road behind mechanical horses weighing some 10 tons are on order in the U.S.A. Some smaller types have been delivered to this country and a few of the larger variety have arrived in the Middle East. The adoption of carriers for all types of tanks would relieve the Ministry of Supply from the limits imposed on designs by railway considerations and would increase the effectiveness of our tanks, especially of the Infantry Mark IV Tank which is not mechanically reliable. The Ministry of Supply are hoping to add considerably to the life of tracks, but this may take time and at present the provision of carriers is of great importance.

RECOMMENDATIONS.

7. (a) Manufacture of the Infantry Mark IV Tank should continue and the detailed modifications should be introduced as soon as possible. Otherwise there would be a considerable period during which we should possess no Infantry Tanks of this type.
- (b) Parallel to the continued manufacture of the modified Infantry Mark IV Tank designs should be completed and development pressed on with an improved Infantry Tank on specifications to be provided by the War Office, after consultations with the Ministry of Supply and manufacturers as to their feasibility.
- (c) If necessary, some of the manufacturing capacity now allotted to the Infantry Mark IV Tank should be diverted to the development of the new tank suggested in (b). Every effort should be made to expedite the production of a pilot model.
- (d) The War Office requirements for spare parts for tanks of all kinds should be given high priority.
- (e) An extension of the tank carrier programme should be considered.
- (f) A tank liaison officer of appropriate seniority should be attached to the Supply Department, and should devote his time to arranging close contact between the users of tanks, both in this country and

other theatres and the Ministry of Supply, especially the Design Department and the trial establishment at Farnborough, in order that defects may be reported and investigated, and the necessary modifications introduced with the least possible delay.

11th December, 1941.

charging set.

regulator.

MOST SECRET

THE MARK IV (CHURCHILL) TANK.

Second Report.

The aim in this second phase of the inquiry has been to ascertain how far, under the existing system, the views of the Army as user of tanks are available to those responsible for supply, namely the Ministry of Supply and the manufacturer; and conversely how far the user is kept in touch with production and modification of tanks. This is especially important in view of the extensive modifications being made to A.22 and of the design of a new model to replace it if necessary.

2. The following have been seen:-

Mr. Harold Macmillan, M.P., Parliamentary Secretary, Ministry of Supply.

Sir William Brown, Permanent Secretary " " "

Major-General Crawford (D.D.G.T.S.) Deputy Director }
General, Tank Supply " " "

Lt.-General Sir Wilfred Linsell, Senior Military Adviser to the
Ministry of Supply.

Sir James Grigg, Permanent Under Secretary of State War Office.

Sir Robert Sinclair, Director General of Army }
Requirements (D.G.A.R.) " "

Major-General Richardson, Director of Armoured }
Fighting Vehicles (D.A.F.V.) " "

Major-General R.M. Weeks, Director-General of Army
Equipment and Acting A.C.I.G.S. + " "

In addition there was an informal talk with Sir Walter Layton, which was useful in confirming and supplementing information obtained from other representatives, and some useful information was obtained incidentally to evidence given on another subject by Major-General Clarke, Director of Artillery before a Joint Meeting of the S.A.C. and E.A.C. on December 30th, 1941. A talk with Field-Marshal Lord Milne was concerned mainly with War Office organisation and does not affect this inquiry very closely.

II.

3. Horizontal liaison between the War Office and the Ministry of Supply is on three levels, viz. the ground floor concerned with detail; the first storey (the Tank Board); the high level (Army Council and Supply Board).

4. On the lowest level, information is exchanged on questions of detail between the Directorate of Armoured Fighting Vehicles in the War Office and two liaison sections in the Ministry of Supply, each containing a number of military officers who now work in close touch with the department of the D.A.F.V. in the War Office. One of these liaison sections is attached to the Director of Design (Mr. Lucas), and the other to the Deputy Director General of Supply (Major-General Crawford). There is no co-ordinating head for the two.

5. Liaison on this level is improving, but does not give entire satisfaction for two reasons:-

- (i) At the outset of the present régime at the Ministry of Supply, officials of the Department, including liaison sections, were discouraged by Higher Authority from visiting the War Office, which caused a temporary break in the continuity of inter-departmental relations. In practice however, this is gradually being surmounted. It was found impossible to make any progress in tanks without the very closest interchange of information and contacts, and these have in practice been resumed.
- (ii) Owing to the partition of the once unified liaison division of the Tank Department of the Ministry of Supply into the two sections mentioned above, one attached to the Design Department (Mr. Oliver Lucas) and the other to the Supply Branch (the D.D.G.T.S., Major-General Crawford).

Confidential Note. These two liaison sections used to form a single Department at a time when design and supply were under one head. Now these two branches are separate and their respective heads are not in very close contact with one another, but they are both members of the Tank Board (see below para. 9) which should to a great extent provide co-ordination. As the War Office must have contact with both Design and Supply and vice versa it was decided to divide the liaison department into two sections. At present each of the liaison sections is under the control of a junior Lieutenant-Colonel and consists of military officers who for the most part have had some service, though usually not very recent or prolonged service in the Tank Corps. General Richardson was not very satisfied with these liaison sections, and thought they ought to be combined under one experienced head, e.g. Major-General Crawford. In view, however, of the fact that Crawford works under Usher in Supply, I do not think he could very well absorb Lucas's liaison section. This is a reform that can only be accomplished from within the Ministry of Supply. General Weeks thought that on this level the liaison was better than is generally realised.

6. General Richardson's Department is in close touch

with the Tank Corps both at home and abroad. In the Middle East the D.A.F.V. who has a small staff sends full information as to tanks in the Libyan campaign. In the past this information was not always passed on to the Ministry of Supply but General Richardson reports that in this respect the two Ministries are now "tied up nicely." We have been informed that the Ministry of Supply have a representative in the Middle East, and that they now pass on information to manufacturers. Major-General Clarke, Director of Artillery, doubted whether, from the point of view of tank design and construction, the technical information from Libya and other theatres of war was nearly adequate. Such questions as the real reasons for failure of a particular tank required greater mechanical knowledge than that possessed by officers of the Royal Tank Corps. In his view the Ministry should send a larger tank mission to the Middle East. III.

7. Liaison on the middle level is provided mainly by the Tank Board composed of -

Mr. Burton (Chairman)

War Office.

A.C.I.G.S. (General Macready)

D.A.F.V. (General Richardson)

Ministry of Supply.

Mr. Oliver Lucas (Controller-General Research and Development)

Mr. George Usher (Director-General Tank Supply)

Mr. Robotham (Chief Engineer on Tank Design).

Major-General Crawford (D.D.G.T.S.) and Colonel Greene of the U.S.A. Embassy attend as tank experts in an advisory capacity.

8. Until recently the Board tended to deal mainly with questions of detail, but at the last meeting it was agreed that more time should be devoted to larger issues, and that questions of policy could be raised.

9. This revised machinery ought to provide adequate facilities for proper discussion between the War Office and the Ministry of Supply and the position is said to be improving.

10. Mr. Burton, the Chairman of the Tank Board, was formerly Director-General, Mechanical Equipment, but now has no executive functions in connection with tanks. He is not a member of the Supply Board and seems to be rather "in the air". For these reasons he is not in a very satisfactory position to co-ordinate the work of the Design and Supply Departments, more especially as the Heads of these two Departments do not always see eye to eye. In case of a difference of opinion Mr. Burton reports to Mr. Rootes, who is the final authority on these matters below the Minister of Supply. A recent example was quoted.

IV.

11. Liaison on the highest level is the point most criticised by those consulted. There was a natural

reluctance to speak plainly on so delicate a matter, but their feelings could not be concealed. The subject raises issues which affect the organisation and conduct of the Ministry of Supply and take us beyond the important question of tanks in general and of the Churchill tank in particular. A plan drawn by Sir Walter Layton is attached, which shows how lopsided the position is. Note especially the peculiar position of Mr. Burton, the Chairman of the Tank Board.

12. Apart from this the system of liaison at the highest level is in theory perfectly sound. The Supply Council, of which Mr. Rootes is Chairman, includes Sir Robert Sinclair, a member of the Army Council and Director-General of Army Requirements in the War Office, as well as Lieutenant-General Sir Wilfred Linsell^d, Senior Military Adviser to the Ministry of Supply, a distinguished and experienced expert on Administrative and Supply questions.

13. In practice, however, under the present régime the Supply Council never meets. Under previous Ministers it used to meet once a week or more. Sir Walter Layton said it was rather large for useful business, but General Linsell^d said it used to take decisions and was an effective body.

14. An Executive Committee of the Supply Council of which Sir Walter Layton is Chairman meets once a week. The Committee was started early in 1941 and used to meet more often under the Chairmanship of the former Ministers. On

the Ministry of Supply side Engineer Vice-Admiral Sir Harold Brown, Controller-General of Munitions Production, and Sir William Brown, when the Minister can spare him, are members. Sir Robert Sinclair represents the Army Council on the Committee. Departmental heads of the Ministry of Supply are brought in to report, as required.

15. The executive Committee^{does} does not deal with policy, and in no way replaces the Supply Council. Its main function is to examine returns of production. It also discusses telegrams relating to production by the U.S.A., and the Eastern Group, as well as the Urgency Production List and similar matters. It fulfils the important function of ensuring that accessories are ready at the same time as the products for which they are required.

16. The real successor to the Supply Council is an informal daily, or nightly, meeting of the Minister of Supply with a group of officials of his own friends in the Ministry, including Mr. Rootes, Mr. Usher, Mr. Lucas, Mr. Paterson and Sir Walter Layton, as well as Sir William Brown. Neither Sir Robert Sinclair nor General Linsell, ~~xxxxxxx~~ ^{the Tank Board}, nor for that matter Admiral Sir Harold Brown are present at these informal consultations.

17. No-one would wish to criticise the right of a Minister to consult those whom he thinks can help him most in the discharge of a peculiarly difficult task, but the

virtual suppression of the Supply Council knocks the bottom out of the liaison system at the highest level, and seriously weakens the position at this level of Sir Robert Sinclair and General Linsell, the representatives of the "user," namely the War Office.

V. SUMMARY OF CONCLUSIONS.

18. (a) On the lowest level liaison on matters of detail between the War Office and the Ministry of Supply has had to develop itself in the teeth of discouragement from the highest quarter, but is now fairly satisfactory and improving. It suffers somewhat from the present partition between Design and Supply of the once homogeneous liaison organisation in the Ministry of Supply. It is difficult to see how it can be much improved under the present organisation of the Ministry. Some improvement might however be made by an overhaul of the military personnel of the Ministry's two liaison sections, so as to ensure that officers with up-to-date experience are included.
- (b) On the middle level the Tank Board should now provide adequately for liaison between the two Departments. Its principal weakness is the anomalous position of its Chairman, who has no executive functions.
- (c) On the highest level liaison is unsatisfactory, but this is not due to defective machinery so much as to the failure to use it properly. The Ministry is ill-organised in the higher levels.
- (d) Vertical liaison is provided by the regular hierarchy of the two Departments, which ensures that officers, officials and Ministers at the higher levels are sufficiently informed of the work and problems and results of liaison on the lower levels. The lack of cohesion which is said to exist between Design and Supply in the Ministry of Supply are a possible weakness.
- (e) A Committee is at present sitting at the War Office to consider certain questions of organisation which

may result in improvements at the War Office end of the liaison system. The Committee is proceeding on sound lines, and it would be a mistake to interfere with it by any recommendations at this stage.

(f) The Ministry of Supply comes well out of the test of quantity of output of tanks. The curve of production is rising rapidly, as it is in other articles of production. By general agreement of witnesses this is due not to the present régime but mainly to the maturity of the arrangements initiated by the Department in the time of previous Ministers of Supply, but tributes were paid to the energy and efficiency of Mr. George Usher.

(g) It is too early to judge by the test of quality, as all the successful tanks were started by earlier régimes. The successful Valentine tank was initiated by Sir Harold Brown, and designed and developed by Vickers long before the present régime. The development of the fairly successful cruiser tank was initiated before the war by Morris Motors, although many mistakes were made, probably owing to inexperience in tank construction, and the present offensive in Libya had to be postponed while certain weaknesses in these tanks were being corrected. The Cruiser tank now seems to have made good. Even the Churchill tank, for which the present régime is responsible was produced in abnormal circumstances under instructions from Higher Authority, and it is too early to say whether it will eventually be a success or not. Experience in Libya confirms that our tanks are all obsolescent.

(h) On the whole so far as tanks are concerned, the present organisation, although far from ideal, is workable, and with goodwill on both sides should secure co-operation between User and Producer. At present however, it is not being operated at the highest level.

Some points of miscellaneous interest are attached in

Appendix I, and a Historical Note on Tank Organisation, which

unfortunately I have not had time to check, is attached in

Appendix II.

Hankey

MINISTER.

Chairman of the Supply Council.
(Mr. Rootes)

Director-General of
Munitions Production
(Sir Harold Brown,
no longer concerned
with tanks, except
accessories.)

Director-General of Design
(Mr. Oliver Lucas)

Director-General
of Supply.
(Mr. George Usher)

Tank Board
(Chairman
Mr. Burton)

Director of Tank Design
(Mr. Durrant)

APPENDIX I.

MISCELLANEOUS.

The following miscellaneous points of interest came up incidentally:-

- (i) The reason why Vickers were not given the work of developing the Churchill tank was that the Chief Designer of the firm (the designer of the successful Valentine tank), after examining the original design for A.22 refused to have anything to do with it.
- (ii) The reasons why Fosters of Lincoln were not employed were first that in pre-war years, being full of commercial work and not believing in the likelihood of war, the firm had refused to accept orders for tanks; and second, that after the outbreak of war they had been willing to develop tanks but not to go into production. They have actually developed the heavy 70-ton tank of Sir Albert Stern's group.
- (iii) Major-General Crawford, the most experienced official of the Ministry of Supply in tank production, is sceptical about the practicability of producing a war-worthy tank from such a defective design as A.22. At present the aim is to make A.22 capable of running 60 miles a day for 6 days a week, and this has been pretty nearly accomplished on two tanks, but he doubts whether A.22 will ever be able to run 1,000 miles on its own tracks, or be fit for conditions comparable to those to which our tanks in Libya are exposed. If this forecast proves true the life of a Churchill tank would be less than three weeks on active service, unless it was found possible to prolong it by using carriers.
- (iv) A.22 will be improved by the provision of carriers, of which some three hundred have been ordered in the U.S.A. and a few (60) at home.
- (v) Mr. George Usher is a terrific driver and for the first time tank supply is making satisfactory progress, though the quality does not inspire complete confidence.

- (vi) Mr. Robotham by general admission is making good.
- (vii) The provision of spare parts is still unsatisfactory to the War Office.
- (viii) A good deal was heard of the desirability of War Office reorganisation in order to remedy the weakness caused by the suppression of the M.G.O., and withdrawal to the Ministry of Supply of all the officers with education, training and experience in the mechanical engineering side of weapons. Many proposals have been made, e.g. the Engineering Advisory Committee's suggestion to re-establish the M.G.O.; Major-General Clark's suggestion to bring back the D. of A. with the Design and Research Departments to the War Office; an idea of Sir James Grigg that the War Office should again become responsible for design and manufacture of weapons, leaving everything else to the Minister of Supply; a reorganisation of the Military College of Science; its removal to Camberley and the raising of the status of its graduates to that of p.s.c.; changes in the organisation of the Army Council itself by putting the C.I.G.S. definitely above the other military members, etc., etc. The whole question, however, is under consideration of a sound War Office Committee and it would be unwise at this stage to offer suggestions.
- (ix) Tank development has been very much handicapped by the constant changes of the Ministers, and the fact that each Minister has either changed the organisation or brought new men into the pivotal positions. In Appendix II will be found a short history as communicated to me by Major-General Crawford. Among the names that flit across the scene are -

Mr. Leslie Burgin
Mr. Peter Bennett
General Davidson
Mr. Hollyburn
Mr. Gardiner
General Hotblack

Mr. Herbert Morrison
Mr. Roger
Mr. Moises
Mr. Thompson
Mr. Geoffrey Burton
Mr. Baker (Chief Engineer of the
Metropolitan Railway)

Mr. Durrant

Sir Andrew Duncan

Lord Weir

Mr. Jimmy Weir

Sir James Lord Lithgow

Major Raikes

Lord Beaverbrook

Mr. Rootes

Mr. Oliver Lucas

Mr. George Usher

Mr. Robotham

General Richardson, and

General Crawford, who, subject to a short interval during which he was withdrawn by the War Office, has been a fixed point in the story.

All these changes have occurred within a few months over two years. The marvel is that there are any tanks at all!

1st January, 1942.

ANNEX I.

INFANTRY TANK MARK IV.

Summary of Papers.

I.

1. The papers on this subject are rather disjointed and not always in chronological order. It will be convenient to begin with a summarised history of the tank. The present pattern known as A22 was based on A20, an earlier pattern, designed to a totally different specification. Possibly this was the first mistake. "Actually the final designs of A22 incorporated but few of the characteristics of A20," but undoubtedly its parentage exercised great influence on such important matters as the selection of the parent firm and on the original design. We must therefore begin with A20.

II. A20.

2. A20 was designed at the beginning of the war to meet a General Staff requirement for a new type of infantry tank capable of crossing wide trenches and able to operate over very soft and muddy country, in short for an attack on the Siegfried Line.

3. The preliminary schemes for A20 were drawn up by the Design Department of the Ministry of Supply in October, 1939. Messrs. Harland and Wolff of Belfast were selected as the parent company -

"to take responsibility for detailed design work, production of detailed drawings and general parentage of the project for design and manufacture."

Why were Harland and Wolff selected? Belfast is a long way from Staines, where the Tank Design Section was established. Was it because Belfast was at that time thought to be immune from the danger of air attack? Or was it that the firm had sufficient capacity and available labour? Or had the firm had previous experience of tank construction? No light is thrown in these papers on this question.

4. Messrs. Harland and Wolff seem to have got on well. Four pilot models were constructed in mild steel, the first of which "ran in the early part of 1940."x Then, and not until then, an order for 100 machines was placed with the firm. Other firms were asked (presumably by Harland and Wolff) to co-operate in the design and the production of individual units, e.g. for suspension, Vauxhall Motors, whose design superseded one prepared by the Design Department; for transmission and steering, Leyland Motors, with the aid of three alternatives for gear boxes and steering, namely Meadows Wilson, David Brown and Merritt Sinclair, and for clutch and operating gears, Automotive Products Ltd.; for tracks, armaments, stowage and general equipment, the Design Department of the Mechanisation Board; for cooling, Davidsons of Belfast were first consulted, and later Vauxhall Motors dealt with this difficult problem.

5. With the collapse of France in June, 1940, A20 was dropped. By that time Vauxhall Motors had come very much into

the picture. Beginning with work on suspension they had now been brought in for the design of a new 12-cylinder flat engine of 350 B.H.P. and for the cooling problems. Hereafter they play an even greater part in the story, for as we shall see later (paragraph 13) they were the parent firm for A22.
destined to become

SPECIFICATION.

III. A22.

6. After the collapse of France the General Staff gave a new specification, including the following -

Speed 16 m.p.h. maximum, 12 m.p.h. average.

Suspension to be designed for big mileages.

Crossing of wide trenches and vertical obstacles not important.

The machine was to be ready in 1941 and large numbers would not be required.

7. The specification was criticised later by the D.D.G./T.D. in the following terms -

"The lay-out of this tank is reactionary in the sense that at the request of the General Staff it was designed to reproduce characteristics of the larger tank used for assault purposes in the last war, rather than the modern conception of the relatively high speed tank capable of long distances, upon which so many years of development work had been expended. The effect, therefore, was to resuscitate most of the unsolved problems of the 1918 tanks, but (it) was not realised that a number of these problems were fundamental to the heavy tank." (Appendix 6.)

8. That criticism, which, incidentally, seems more applicable to the specification for A20 (para. 2 above) than that for A22, was not made until 6th September, 1941, more than a year after the specification for A22 was adopted. It should have been made at the time. But there is no evidence in the papers -

- (i) That the General Staff consulted the Ministry of Supply about the practicability of designing a suitable tank to meet their specifications.
- (ii) That the Ministry of Supply asked for such consultations. It is noticed that the War Office (the user) were not represented at the preliminary meeting on June 12th, 1940, to settle the design. (Main Report, page 3, para. 2.)
- (iii) That any joint consultation took place between the supplying department and the using department about the specification or the design.
- (iv) That the General Staff consulted the Heads of the Tank Corps about the specification or design - but that, of course, would not appear on Ministry of Supply papers. The General Staff might be questioned on this point.

CTION OF
SHALL
STARS AS
PARENT FIRM
FOR A22.

9. After the issue of the specification the Design Department (which had now moved from Staines to Southall, Middlesex) worked out the preliminary schemes for A22. Messrs. Harland and Wolff appear no more in the story, as Vauxhall Motors, who had been introduced to the problem of tank design by their work on the A20 engine, cooling and suspension, were chosen as the parent firm for the new design. The reasons given in the official papers are

"Because of the great interest Messrs. Vauxhall Motors had taken in the work, and the facilities they possessed for research and development, it was clear they were well fitted to act as parents for the new design....." (Main Report, page 3, para.2(3))

The firm accepted responsibility on the 22nd June, 1940.

10. High tributes are paid throughout the official documents to the energy and skill of this firm, but prima facie the results do not appear to justify these encomiums from the point of view either of design, detail or workmanship. Moreover the firm had had little, if any, experience of tanks, track-laying vehicles or heavy vehicles above lorries of about 30 cwt. Neither this firm, nor any of those mentioned above appear in the Official History, Ministry of Munitions, Volume XII, Tanks, as having taken part in tank production in the last war. Whether any of them constructed tanks after the war is not known. Moreover Vauxhall Motors were criticised afterwards as having been responsible for the parts of the tanks which were found most defective, especially suspension, described as "the outstanding problem." (Main Report, page 3, para. 5) Would not this be expected with a firm connected mainly with light motor cars and lorries and unaccustomed to either tanks or heavy motor vehicles?

LACK OF CO-
OPERATION
BETWEEN
D.T.D. AND
THE FIRM.

11. While the tank was being constructed certain leading designers of the D.T.D. staff were sent to Luton to "join Messrs. Vauxhall Motors in launching the new schemes." This process began on the 27th July, 1940, and the staff remained with the firm until the 14th September, 1940. Dr. Merritt, the Head of the Design Division, was also stationed at Luton. It is clear from the main report (page 4) that this plan did not work very well.

"In these very early stages, however, matters were made difficult by the presence of a representative of the Ministry of Supply Production Department (Major Raikes) and questions of design were often disposed of by reference to Major Raikes, rather than by seeking the advice of the D.T.D. Design staff present. After the Design Staff left it became even more apparent that Messrs. Vauxhall Motors did not intend to consult D.T.D. and evidently trusted their own people to make a satisfactory job of the tank. Whenever D.T.D. officers attempted to follow the development of the design and to express opinions on how certain matters should be dealt with, they were faced with the fact that the firm was vested with full responsibility for all the main activities on the development of the tank, and considered that they were the final authority on matters of design."

From the above it is clear that any lack of co-operation was not due to D.T.D. and its staff.

MODIFICATIONS.

12. Under the parent company's scheme modifications before being introduced into the tanks were to be approved in design form by the D.T.D. before being passed by the parent

company to manufacturers. In the case of A22 however, Vauxhall Motors did not comply with the scheme. They introduced modifications that they deemed necessary, though copies of the finalised detailed modifications were sent to the D.T.D. for his information. The attention of the D.D.G./T.D. (Mr. Lucas) was drawn to this on the 5th August, 1941, but we are not told what was the upshot.

PRODUCTION.13.

During the process of production great difficulties arose owing to pressure from some quarter unspecified for early supply. The officials of the Tank Design Department gave constant warnings, but they do not seem to have been regarded. As early as the 11th November, 1940, warning was given by D.T.D. to D.G.T.T.

"drawing attention to the risk of a prolonged development period before the machine could be regarded as a fully reliable and serviceable unit." (Main Report, page 4, last para.)

If the Ministry of Supply were cautious, the Firm seems to have taken the opposite view and wanted increased orders even before the pilot model had been handed over and regardless of the statement in the War Office specification that large numbers would not be required. (Para. 6 above)

x An obvious misprint for 1941.

"At the meeting held at Luton on the 12th February, 1940^x the firm pressed the representative of the Ministry to push the figure of one per day up to ten per week. Although during the design of this particular tank the need for large numbers of tanks became more and more urgent, the wisdom of applying so large a scale of production to so new and untried a machine caused great concern to those who had had previous experience of tank work." (Main Report, page 4 para 4.)

PRODUCTION OF A22.

14. The first pilot model of A22 was not received by the Experimental Wing of D.T.D. until May 24th, 1941, eleven months after the firm had accepted responsibility. Incidentally it should be noted that this compares badly with A20, the first pilot model for which, it will be remembered, ran in the early part of 1940, though the parent firm, Harland and Wolff had only taken responsibility in October 1939 at earliest. It should be noted also that early production of pilot models is a point on which the Engineering Advisory Committee lays great stress (A.C.E.(41)39, paras. 30 - 35).

15. To return to A22, very serious defects were revealed from the outset of the tests. In spite of this, to the horror of the Officials of the Design Department the tank was put into production, and even issued to units of the Tank Corps although still untested and unaccepted. The Officials issued repeated warnings. Thus, apart from the warning of 11th November, 1940, quoted in paragraph 13 above, a Design and Experimental Meeting on 16th May, 1941, endorsed a recommendation that had already been made by Mr. Durrant, one of the leading design officials, in favour of curtailing the production of Tank, Infantry, Mark IV, until the reliability of the machine had been proved. (Appendix I to Main Report). Again on the 12th September, 1941, D.T.D. reported that infantry tanks Mark IV were being issued by Vauxhall Motors to the Service, though they "were still only in the development stage, and D.T.D. had not accepted the machine as a whole." The opinion was expressed "that production of the machine should be stopped until sufficient development work had been carried out to ensure some finality of design, which would result in the production of an efficient fighting machine."

Once more -

"Warning was given by D.T.D. in a Minute addressed to D.G.T.T. on 11th November, 1941 drawing attention to the risk of a prolonged development period before the machine could be regarded as a fully reliable and serviceable unit." (Main Report, bottom of page 4.)

But production still went on, and to judge from these papers continues to-day. The papers do not reveal who is responsible for the decision.

DEFECTS.

16. The defects of the infantry tank, Mark IV, are very extensive. The main defective units include - mudguards, suspension, engine, gear-box, steering brakes, cooling system, petrol system, electrical equipment (para. 5 of Main Report). Suspension, as already mentioned, is the "outstanding problem." The Appendices reveal many additional defects. In Appendix 5, for example, the fundamental defects are stated to be the layout of the machine, suspension and cooling. In addition are mentioned a number of detailed defects including track, engine, gear-box, clutch, final drive, parking and steering brakes, petrol system, turret, electrical system, mudguards. Many of the difficulties are said to be aggravated by a poor standard of workmanship. Appendix 10 mentions no less than 99 items in which defects were found, many of these, of course, being in the nature of teething troubles.

17. The following are some of the comments picked out from the various minutes in the Appendices -

"In the case of the engine, for example, this has not yet been able to pass its acceptance type test. This is a 100-hour test and, so far, I understand that the engine has only been capable of doing about 9 hours." (Appendix 3, 20th July, 1941).

"Broadly speaking, in an attempt to provide a generous fighting space in a large heavily armoured tank, insufficient space has been allotted to accommodate the machinery likely to provide a reliable service, and it may safely be said that all the major troubles experienced are due to the various expedients which have been adopted in order to obtain this end." (Appendix 6)

A minute to A.D.D. from D.D.G./T.D. dated 6th September, 1941, Appendix 6, speaks of

"fundamental errors in the layout of the machine."

The minute continues -

"It can safely be said that, although nothing is impossible, the prospect of making this vehicle reasonably reliable at the speed originally specified is sufficiently remote to place it in the category of the practically unattainable.

If, however, General Staff are prepared to drastically cut the maximum speed, not merely for training purposes, but for battle as well, it should be possible to eventually produce a vehicle having a ~~large~~ standard of life and reliability equal probably to the less satisfactory fighting vehicles at present in service, and it is important to realise that this can be attained within a reasonable period only if considerably less emphasis is laid on production, as there can be no doubt that the resistance to

change imposed by a high pressure production programme is seriously militating against the introduction of urgent modifications."

"there is no justification for assuming that this vehicle could be put into service in a reasonably reliable form without devoting at least another year to intensive development and testing There is not a single precedent in the whole history of vehicle development which would justify any other presumption." (Minute by Mr. Little to Mr. Durrant, and passed by him to D.G.T.T. with a comment which includes the following -

"There is a real risk of a prolonged development period before the A22 machine can be regarded as a fully reliable and serviceable unit." (11th November, 1940)

In an unsigned minute however dated 1st July, 1941 (Appendix 10) occurs the following -

"It is considered that it would be very inadvisable to withhold delivery of tanks to units pending the rectification of the difficulties. The result of this would be to clog the production lines of the assemblers, and to break down the entire organisation that has been set up to produce the vehicles. None of the defects are as serious as to offer no prospect of reasonably rapid rectification, and it is felt that the issue of vehicles should proceed, but that units should be instructed to drive them at low speeds and to avoid unnecessary wear and tear."

18. The remainder of the papers from Appendix 10 onwards consist mainly of reports of running experience at Farnborough. They contain an appalling list of defects, far too numerous to attempt to summarise. They appear to affect almost every part of the tank. Mud seems to have penetrated everywhere inside and outside the tank, covering the look-out places, the radio communication apparatus and filling the 3" howitzer and the 2" bomb thrower, jamming the drivers and front gunners periscopes, stiffening the turret and rotating commander's look-out, and generally upsetting the control of the machine. The engine was reported to take six days to remove - but these are only one or two items out of dozens.

Will delete.
22/10

SECRET.

10.10.41.

NOTE ON PRESENT POSITION OF TANKS.

(By W. Richards)

The present situation as regards Tanks is very disquieting and has been brought into prominence as a result of the recent large-scale manoeuvres.

In brief the position appears to be that of the five different types of Tank now in production, two only are even reasonably reliable from a mechanical point of view, namely, - the Vickers "Valentine" and the Morris "Crusader" - these are both relatively light machines and are regarded by the Military as too small and too lightly protected to face a German Tank.

Of the larger machines the Infantry Mk.II, though well protected, has always been, and still remains, so unreliable that it can hardly be regarded as a satisfactory fighting machine, except within easy reach of a fully-equipped repair base.

The most disquieting feature of all, however, is the position as regards the heavy 38-ton Mk. IV (Churchill). This machine is now being put into production on a vast scale, and a very serious proportion of the manufacturing facilities of the country is being devoted to its production. Messrs. Vauxhall Motors, Harland and Wolfe, Leyland Motors and others are all fully engaged upon it, while dozens of firms are sub-contracting components.

Put quite crudely, this Tank simply does not work, nor does there appear to be any prospect of making it work without very radical alterations, as to the nature of some of which no two people are agreed.

INFANTRY MK.IV (CHURCHILL).

This is a relatively heavy tank of about the same weight as those used in the last war. It was designed at Woolwich with an anticipated weight of 28-tons and was to be propelled by a 240 H.P. Meadows petrol engine. The transmission gearing (in this case of the controlled epicyclic type) was designed by Messrs. David Brown. It mounts a two-pounder gun, a 3" short howitzer or bomb thrower and one machine-gun - a very inadequate armament it would seem for so large a machine.

Its protection consists of 90 m.m. frontal armour, 50 m.m. side armour and a 63 m.m. plate protecting the rear; the roof protection, however, is only very light plating.

One or more prototypes of this machine were completed at Belfast early in 1940. The first trials showed -

- (1) That the weight instead of 28-tons was actually about 37 tons - it has since grown to 38½ tons.
- (2) That the engine power was not nearly sufficient.
- (3) That both tracks and suspension were heavily overloaded.

Vauxhall Motors were then asked as quickly as possible to design and develop an engine of 350 H.P. to replace the Meadows, this they achieved with remarkable promptitude. Equipped

Components.

(1) Engines. In the last war it was realised at the very outset that the conditions prevailing in a Tank called for a very specialised and unorthodox type of engine, and a full range of engines from 100 to 330 H.P. was designed in 1916 and at once put into production. The specialised conditions were:-

(1) Cooling.

- (a) In a Tank the entire cooling system has to be enclosed within the armour-plated hull.
- (b) The cooling medium (air) must be introduced and discharged through bullet-proof apertures which must be kept as few and as small as possible.

In view of the above considerations it was obvious that the cooling air must be strictly rationed and that the engine must be so designed as to dispose the minimum possible waste heat to the radiators - this was achieved by:-

- (a) Separating the pistons from the crankcase and cooling them independently by the air induced through the carburettors; this served the double purpose of relieving the radiator from a considerable part of its duty, and, at the same time, obviated the necessity for oil cooling.
- (b) The exhaust passages contained in the water-cooled cylinder (from which the intensity of heat flow is very high) were reduced to the absolute minimum.
- (c) Wherever possible the cooling was carried out regeneratively.

(2) Heat Radiation. It was realised that, if the crew were to be kept reasonably comfortable, and the risk of gas locks in the fuel system avoided, steps must be taken to prevent, as far as possible, any radiation of heat from hot surfaces, such as exhaust pipes; these, therefore, were air jacketted, using air which had already passed through the radiators; at the same time, in the event of any leakage of the exhaust due to a faulty joint or cracked pipe, the escaping gases would be carried safely away by the jacketting air.

(3) Gas Poisoning. In order to obviate any risk of this:-

- (a) The engine crankcases were sealed hermetically and maintained at a pressure below atmosphere - any fumes from the crankcase were exhausted and subsequently discharged into the exhaust.
- (b) The whole of the interior of the Tank was maintained at a pressure above atmospheric by a separately-driven fan, so that any fumes from the gun barrels or empty cartridge cases were discharged outboard.

(4) Lubrication. It was laid down that under no circumstances must the engines show smoke from the exhaust, lest the position of concealed Tanks be disclosed. This called for a very special and unorthodox system of lubrication so arranged that the oil supply to the pistons was cut down to the absolute minimum when idling.

Each and all of these lessons based on forethought and experience appear to have been forgotten entirely, and to-day we are suffering from troubles many of which we had anticipated and overcome by 1917. To-day our Tanks are equipped with a miscellaneous collection of engines, all being either adaptations of engines designed for quite other purposes, or hastily designed improvisations, such as the Vauxhall.

Since the last war the declared policy of the War Office has been to make use for Tanks of such commercial vehicle petrol engines as might be available; this policy was maintained almost till the outbreak of the present war, when the War Office suddenly realised that no commercial vehicle engines were being developed of appreciably over 100 H.P., while the very minimum required by any Tank was 150 H.P. It was their policy also to use only petrol engines on the perfectly logical grounds that Military transport vehicles used petrol, and that it was undesirable to have to supply two different fuels. During the last ten years, however, the high powered petrol engine for road service had been displaced almost completely by the Diesel; thus there were no high-powered petrol engines available and even the more powerful Diesels fitted to heavy commercial vehicles were not nearly powerful enough. Instead of setting to work to develop a suitable engine or range of engines as was done so successfully even in the middle of the last war, an excess of compromise was adopted, with the result that no two types of Tanks share the same or even similar engines; there is no consistency as to fuels, for some Tanks have Diesel engines, others petrol.

It will be observed that the smaller powered Tanks are equipped with Diesel and the higher powered with petrol engines, the converse of commercial experience and usage.

Guns.

All our Tanks, light and heavy, are each equipped with one 2-pounder high-velocity gun mounted in a power-operated turret, with one or more 7.92 m.m. B.E.S.A. machine guns as secondary armament.

The 2-pounder is said to be an excellent gun with a muzzle velocity of about 2,800 ft. per sec. Firing solid armour-piercing shot, it is said to be able to penetrate 40 m.m. armour with normal impact at 100 yards. With capped shot the penetration is reported to be increased to 50 m.m. Until comparatively recently the War Office have insisted that this gun is amply powerful for any Tank and that nothing larger can be anticipated, hence all Tanks are designed to mount it. More recently, as a result of urgent pressure from many quarters, a six-pounder gun of similar muzzle velocity has been developed but as yet no turret suitable for mounting in a Tank exists, nor has any decision yet been reached as to how such a turret should be operated, whether hydraulically or electrically. None of the Tanks at present available except the T.O.G. are capable of accommodating a 6-pounder without extensive modification. A modified version of the Cruiser Mk. VI is, however, being developed to mount a 6-pounder in a turret designed by Messrs. Stothert & Pitt of Bath.

There is also in hand a modified version of Infantry Mk. III to be used as a gun carrier carrying a 25-pounder gun in much the same manner as we modified the much larger Mk. V Tanks in the last war, to carry either a 60-pounder or an 8.2" howitzer.

As to Infantry Mk. IV, until the tracks and suspension have been greatly improved, there is little prospect of this heavily overloaded machine being able to carry a much heavier gun and turret. It appears that the Military authorities have now swung to the other extreme and are demanding that Tanks shall be equipped with 3-inch 17-pounder guns, but except for the T.O.G., no Tank yet designed could mount such a gun or accommodate its heavy and bulky ammunition.