~~SECRET~~

History of the Americanization

of the

BOFORS 40mm AUTOMATIC ANTIAIRCRAFT GUN

Being the chronological record of procurement of manufacturing rights by the United States Government; of cooperation between the Army and Navy in purchasing it and then coordinating production for both services; of facilities chosen to make its components, and their contributions toward its improvement; of its perfection under American mass production methods; and of the numerous attempts--successes and failures--to adapt it to many combat uses. Appended are tables of production through 31 December 1943 and a table of price reductions on the gun's principal components.

OFFICE, CHIEF OF ORDNANCE

Historical Section

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~~Confidential~~

The 40mm Automatic Gun, M1, Materiel

Remote from each other in practically all respects, the Spanish Civil War of the late 1930's, curtain-raiser for World War II, and the British evacuation of Dunkirk in May 1940, had one important thing in common: They proved the superiority of the Bofors 40mm automatic antiaircraft gun. Both focused world attention on a weapon which had already engaged the interest of military men in many countries, and called for specific comment by those of the Ordnance Department of the United States Army charged with the design or procurement of a satisfactory automatic antiaircraft gun of intermediate size.

Considerable thought and development work had been put on the design of an American 37mm gun having the desired characteristics, but the Ordnance Department was overlooking no possibilities. Hence a careful watch was kept on foreign tests of such materiel. In 1934, European tests of a number of such weapons were made, and when these were ended in May 1935, the Bofors 40mm automatic antiaircraft cannon was adopted as standard equipment for antiaircraft artillery in Belgium. (1)

From those tests, in which the competitors were three 20mm guns, two 25mm guns, a Schneider 37mm gun, and a Vickers 40mm gun--all of

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1. G-2 Report, 2296-428-1, November 27, 1936, Captain René R. Studler, Asst. Military Attache, London, England.

foreign make--it was concluded that the 37mm was the minimum acceptable for antiaircraft artillery and that the 40mm was preferable. Later, Bofors was invited to submit a 40mm gun, and after its further test, Belgian personnel were "highly enthusiastic about the Bofors 40mm which is considered much more accurate than the Vickers." (2)

Principal characteristics of the test-Bofors, which takes its name from its originator, Aktiebolaget Bofors, of Sweden, were as follows: (3)

Caliber	40 millimeter
Weight of projectile	2.1 pounds
Muzzle velocity	2,950 foot-seconds
Range, maximum time of flight for H.E. shell	9,300 yards
Rate of fire	100 to 120 rounds/minute
Weight of gun (firing or traveling position)	3,800 pounds
Elevating field (carriage)	-5 to +90 degrees
Traversing field (carriage)	360 degrees

In May 1937, the Ordnance Department attempted to obtain a Bofors gun from the makers for test purposes, but Aktiebolaget Bofors replied that "...we are unfortunately not in a position to provide... the materiel asked for, as we on principle do not sell guns and ammunition for demonstration purposes." (4)

In the third indorsement to that letter, Major General A. H. Sunderland, Chief of Coast Artillery, reiterated his comments, which he said had been in previous correspondence, as to his "firm belief in the necessity for the early development, for the U.S. Army, of an effective intermediate caliber AA gun"; and further, "My belief in the efficiency of intermediate caliber AA weapons, utilizing explosive

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2. Ibid.
3. Ibid.
4. Letter O.O. 400.136/1017, June 12, 1937, from Truman Smith, American Embassy, Berlin.

bullets, is but strengthened by reports of the outstanding success of these weapons in the hands of the Insurgents in the present Spanish Civil War. These guns are credited with bringing down a large percentage of the planes destroyed. It is understood that your investigation of the various weapons likely to be suitable has incicated that the Bofors 40mm AA gun gives the greatest promise. Evidence that this estimate is correct is furnished by press dispatches reporting that the British Government has recently placed with the Bofors Company an order for several million dollars worth of these guns."

The Chief of Coast Artillery went on to say that "...efforts to determine the suitability of the Bofors 40mm gun should be continued with renewed vigor," and suggested that Ordnance officers be sent to the Swedish plant to witness a demonstration of the equipment. Captain R. R. Studler, Assistant Military Attache, London, and Major Gordon B. Welch were given the assignment and made their report after witnessing the demonstrations 18 and 20 August 1937. (5) As a consequence, the Chief of Ordnance cabled the Military Attache in Berlin to obtain quotations on Bofors 40mm AA materiel, (6) and received the reply that the Bofors firm could not make delivery of guns and ammunition in less than two years and that they proposed to sell manufacturing rights. (7)

This is, so far as the record shows, the first concrete step toward

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5. 18 September 1937, O.O. 472.91/1477.
6. 6 December 1937, O.O. 400.136/1029.
7. 22 December 1937, O.O. 400.136/1030.

the ultimate procurement of the Bofors 40mm AA materiel by the Army's Ordnance Department. Yet on receipt of the above-mentioned Bofors letter, the War Department made a distinct about-face. In the second indorsement, dated 4 February 1938, the opinion was cited that, "In view of the fact the procurement of intermediate caliber weapons from foreign sources is not favorably considered by the War Department, which is now concurred in by the Chief of Coast Artillery, this office recommends that no further negotiations be carried on with the Bofors company looking toward the procurement of materiel discussed herein." The 37mm AA gun still held promise, for a German gun of that size had also done effective work in Spain. (8)

Only a few months had passed when Aktiebolaget Bofors abandoned the role of pursued and became the pursuer. Whereas, formerly, they had courteously declined, "on principle," even to sell guns and ammunition for demonstration purposes, they now offered (9) to send a pilot gun for trial purposes, and also "our Commander Bostrom together with one engineer and one mechanician to the U.S.A. free of cost." They offered to supply 2,600 rounds of shell of several types for six to twelve dollars a round, the total cost figuring "20,200. and asked that the test be concluded quickly and the gun returned.

This was quite a concession but, despite the often emphatically expressed purpose to obtain the gun for the United States, the Ordnance Department declined the offer, saying that it was "...impractical to conduct test of 40mm at this time." (10) No reason was

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8. Memo, Maj Gen C. M. Wesson to General G. C. Marshall, no file number, 17 January 1941, W. E. Yocum's file.
9. 27 May 1938, O.O. 471.91/2586.
10. Letter to Military Attache in Berlin directing that cable be sent to the Bofors company, O.O. 471.91/2595.

stated but conversations now reveal that the cost of the ammunition was too great for a peace-time test. (11) It is now apparent that that decision was based on a misreading of the Bofors cable, so that the amount involved was believed to be $243,600.00! (12)

Before the confirming letter from Bofors could arrive or an answer be obtained to the letter the Office of the Chief of Ordnance wrote to the Berlin Military Attache (13) asking his checking of this unreasonably large quantity of ammunition for a test of one gun, the decision had been made.

That decision turned American attention again to our own 37mm AA gun on which considerable effort was expended for its further development and manufacture in large quantities even though it was already believed inferior. That decision delayed for about two years more the adoption of the greatly superior Bofors 40mm AA gun. That decision made necessary the costly duplication of effort in the later testing of

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11. With engineers still in O.D. in 1944 who were involved in the Bofors discussions in 1938; and from letter O.O. 471.91/2583, of 25 May 1938 which clearly implied that the test would be run if reasonable amounts of ammunition could be specified by Bofors.
12. Lack of punctuation in the cablegram, failure to mention the word "dollars" except toward the end of message, and the belief of the recipient that the sender's method of writing 10,000 was "10 1000" caused the error in reading the cablegram which was as follows: "referring conference 26/4 Ordnance Department Commander Bostroem Stop 40 M/M pilot gun and ammunition can be sent about 15/6 costs of freight to be paid by Bofors stop FOB price New York City 500 rounds of high explosive tracer shells 10 1000 tracer drill shells 8 1000 drill shells 6 100 armour piercing tracer shells 12 100 ditto uncharged 12 dollars a piece stop please cable confirmation." Consequently, the quantities of shell were read, respectively, as 500, 10,000, 8,000, 600, and 1,200, or a total of 20,300 shell at a common cost of twelve dollars each.
13. Letter O.O. 471.91/2583.

the gun by the Army and the Navy, separately, and their dual development of plans for its manufacture under the intense strain of our National Defense period.

The war in Europe began in September 1939, and the Bofors gun was given full test in battle. Its reputation grew even ahead of that which it had earned in the Spanish Civil War, for aircraft were immediately employed as offensive weapons to an extent previously nothing but theory. The technique of dive bombing was quickly perfected and used against land targets as well as shipping. Planes flew low enough to strafe troop concentrations and moving lines of refugees.

For defense against such low-altitude operations, it was generally believed by Ordnance men that the Bofors 40mm AA gun did not then have a peer anywhere in the world. It fired a heavier shell than the American 37mm gun and with a greater muzzle velocity, while it had the advantage of its high explosive shell over the caliber .50 machine gun, the bullet of which then had to hit a critical part of a plane to be effective. An additional point of superiority was its tube which could be removed in about two minutes and replaced by another.

Just after the United States entered its National Defense period, declared by the President in September, 1939, the Swedish Legation, acting in behalf of the Bofors company, opened negotiations with the York Safe and Lock Company to have that company consider manufacture in this country of the Bofors materiel in accordance with the drawings of the Swedish firm. To York's query (14) as to the legality of such

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14. Letter from York to Chief of Ordnance, O.O. 472.93/6883, 27 Oct 1939.

manufacture, the Chief of Ordnance replied (15) that there would be no objection to the undertaking provided it did not interfere with any work for the Ordnance Department. York made no arrangement with the Swedish firm at that time although, later, the company did make the Bofors 40mm gun for the Navy. And therein lies a story of close coordination of effort between the Army and the Navy which was then without parallel for such major materiel. The fact that these two services met on common ground for greater efficiency and faster production is less a coincidence than it is a testimonial to their viewpoint and to the wide utility of the weapon.

Like the Army, the Navy had been interested in the Bofors gun for some time, but did not succeed in obtaining a gun for test until about the time the Army also obtained one. This was in the latter months of 1940, from which point onward the story of the American Bofors rapidly takes on a dual Army-Navy role.

The epic evacuation of Dunkirk, France, in May, 1940, by the defeated British Army and small remnants of French, Belgian, and Netherlands units, had shown emphatically the superior qualities of the Bofors 40mm AA gun. On the Dunkirk beaches, it was an outstanding success as a defensive weapon against swarms of low-flying German planes strafing the disorganized Allied troops, as well as against mechanized ground forces.

On 2 September 1940, the Army's Chief of Staff, General George C. Marshall, wrote to Sir Henry Tizard, Chief of the British Technical

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15. Letter O.O. 472.93/6889.

Mission, stating the Army's desire for a battery of four British 40mm Bofors guns and a complete set of fire control instruments, including the Kerrison Predictor. (16) Sir Henry replied that he doubted that four would be released, but that one complete gun and equipment should give all data required. (17) This British gun was delivered at Aberdeen 19 November 1940.

In the meantime, the Navy had ordered a Bofors 40mm AA twin mount gun in August, 1940, which was delivered in October, and had obtained from the Dutch, in September, drawings of the gun and of the superior Dutch fire control equipment. Rear Admiral W. H. P. Blandy explains that the story that these drawings were flown out of the Dutch East Indies barely in time to escape the oncoming Japs is apocryphal: "a lovely story but untrue." (18)

Admiral Blandy (then Captain) had been told by a Dutch admiral of the excellence of the Dutch fire control equipment and it was suggested that he might wish to see it in action on a Dutch ship soon to make the West Indies. Admiral Blandy went down with an American cruiser which could launch planes to tow targets, and was so impressed with the firing data that he arranged to have the drawings microfilmed

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16. Letter O.O. 472.93/270 which says, in part, "...Our Ordnance people believe that such a test (comparison with the standard American 37mm AA gun and equipment) would also be of importance to the British Government in view of the expressed desire to purchase 37mm AA guns and fire control equipment in this country. Undoubtedly these tests would indicate to both governments which type of material is superior."
17. Letter O.O. 472.93/270.
18. Article by Rear Admiral W. H. P. Blandy in files of Navy Department, unpublished.

at Surabaya, Java, and flown to this country. (19) (Such drawings were not available from Holland as that country had already been overrun by the Germans.)

The Navy's Bofors 40mm AA twin mount was proof-fired at the Navy's Dahlgren Proving Ground (Virginia) on 15 October 1940, with several Ordnance Department officers and engineers present. Just over a month later, 25 November, the Army tested its British 40mm Bofors AA gun with a British gun crew at Aberdeen. Several naval officers and engineers were present to examine the materiel and witness the firings. This same British Bofors was again test-fired at Fort Monroe on 9 December 1940.

These firings were all successful, but of outstanding interest to all observers was the marked superiority of the British fire control equipment. In a secret communication to the Secretary of War, the Chief of Ordnance said, on 12 December, that "The United States is... considering the adoption of the Kerrison Predictor and remote control system pertaining to the Bofors materiel for use with our 37mm AA guns." (20) He was writing of the critical need of the British for additional Bofors 40mm AA materiel at that time, and went on to say that, to meet their needs, new facilities would have to be set up for either the U.S. 37mm or the British 40mm. "In view of the exceptional conditions and the urgent desire of the British forces to augment their 40mm AA guns by this same type of materiel..." he recommended that the British

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19. Ibid.
20. Letter O.O. 400.3295/1531.

be authorized to place orders in this country.

An advantage to the United States was seen in this sort of arrangement, as it would create new facilities for the manufacture of the Bofors materiel which would be turned to good account if we desired to obtain this equipment for our own troops. (21)

Not only were Army officials still debating the practicability of making the Bofors in this country, but they were between the Scylla of the nation's wish to assist the British to the fullest measure and the Charybdis of our own intensifying National Defense effort. We were making 37mm guns at the rate of 40 a month and had ordered a total of 3,195 guns and carriages and 4,500,000 rounds of ammunition. It was believed by some that, to make the 40mm in lieu of the 37mm AA materiel, would cause a delay of at least a year in obtaining antiaircraft materiel of this type. (22) More important results in our rearmament program could be obtained, it was thought, by adapting the Kerrison Predictor and Power Control to our 37mm AA gun; and that was the intention in December 1940. (23)

Sound logic lay behind this apparent indecision, this difference of opinion: The need to conserve our plant facilities and consideration of the necessity for quick conversion to our own production should emergency arise. Hence the decision of 2 January 1941 to permit manufacture of Bofors guns for the British in this country was hedged "with the proviso that this will not establish a precedent for the substitution of other non-U. S. standard items in the British 'B' program." (24)

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21. Memo to Deputy Chief of Staff, Brig Gen R. C. Moore, O.O. 472.93/597.
22. Ibid.
23. Ibid.
24. Ibid.

Late in January, the Bureau of Ordnance, Navy Department, informed General Barnes of the Ordnance Department that Aktiebolaget Bofors was willing to license the manufacture, for use by the U. S. forces only, of the latest type Bofors 40mm water-cooled AA gun and twin naval mount. The license cost would be $600,000; and drawings and the services of a production expert and a design engineer would be furnished. (25) A license to manufacture ammunition would cost an additional $250,000.

Consultations were held and correspondence passed between the Army and the Navy with a double result. First, the Bofors company reduced their price to a flat $600,000 for license to manufacture the naval mount, an Army mobile AA gun and carriage (the latter as covered by U.S. patent No. 2,103,670) and ammunition for both these guns. Blueprints, manufacturing drawings, and the services for one year of two production experts were also to be supplied. (26) Secondly, the Army agreed, (27) on 4 June 1941 to pay half the cost of this license, or a total of $300,000.

Before this time, an Ordnance Committee Meeting had, on 6 February 1941, approved the Bofors light antiaircraft gun for adoption as standard, while the 37mm AA gun and carriage were to be redesignated substitute standard. (28) Manufacturing rights were to be sought, drawings were to be prepared, components and major assemblies were to be interchangeable as between British and United States Army

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25. Memo O.O. 472.93/2553, of 23 January 1941.
26. Memorandum O.O. 472.93/2447.
27. Memorandum O.O. 472.93/2500.
28. O.C.M. Item 16448, 4 Feb 1941.

Ordnance-made units, two complete pilot units were to be manufactured, two guns and carriages with two spare barrels and all equipment were to be procured from the British, and, finally, the designations were to be Gun, 40mm automatic, T1, and Carriage, 40mm Gun, automatic, T1. These designations were both changed to M1 in April, 1941 (29) in an O.C.M. item which specified, among other things, that it would definitely replace the 37mm materiel, though this latter would be kept in service and production contracts for it would be completed.

By the time these classifications had been recorded, and before the Navy entered into a contract with the Bofors company in June, a number of manufacturing details had been discussed and worked out. In his memorandum of 17 January 1941 to General Marshall, the Chief of Ordnance, Major General C. M. Wesson, stated that he had forwarded to the Chrysler Corporation one British Bofors 40mm gun (that tested at Aberdeen and Fort Monroe) and had asked the president of the corporation to submit a proposal for the manufacture of about 1,000 of these guns desired by the British Government. (30) "Facilities thus will be built up in the United States," he said, "for the manufacture of the Bofors materiel which also can be utilized by this Government." It was in this memo that a promise of the future was contained in his remark that, "when manufacturing rights are obtained... it will be possible for both the Army and the Navy to manufacture these

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29. Ordnance Committee Meeting Item No. 16647, 9 April 1941.
30. Memo to the Chief of Staff, stated date, no file number; W. E. Yocum's file.

under one license."

It was generally understood, it will be noted, that the Army was to prepare the way for possibly large American production of the gun by filling the current needs of the British Government, by making and testing two complete pilot guns of its own, and by adapting the Kerrison Predictor and fire control equipment to the 37mm AA gun. All this in spite of the fact that no license had been obtained for American manufacture of the gun for American use. It is true that the decision had been made rather early in the year to obtain manufacturing rights to the gun itself, for joint use by the Army and Navy, but light had still to be thrown on the patent situation on the Kerrison Predictor and the British remote control system.

The Chiefs of the Fire Control Section, R. C. Darnell, wrote a memorandum (31) to Major W. J. Rowe on 10 February saying "The general policy is to secure release for manufacture in this country, which has been granted in the case of the subject equipment (the predictor and control system) and proceed without consideration of the patent infringements involved." The implication was that the patent situation could be straightened out after the war. On this subject, the Secretary of the Navy had issued a circular letter to the same general effect. (32)

As to the carriage, it was learned that several of its patented features are controlled by a private concern in this country,

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31. No file number. Copy in W. E. Yocum's personal file.
32. Ibid.

and it was feared that these patent rights would be held unreasonably high. Nevertheless, it was felt "that the description of the 40mm materiel...is sufficiently broad to permit the substitution of American-made equipment or mechanisms in lieu of Bofors patented mechanisms."(33)

These comments cleared the air a bit for completion of the two pilot guns which had been ordered from the Chrysler Corporation under a Development and Manufacturing Contract dated 3 February 1940. (34) The contractor was to prepare and complete detailed drawings for the 40mm gun from drawings supplied by the Ordnance Department, these having been obtained from the British; and from a study of the British Bofors gun which had been tested at Aberdeen and Fort Monroe and then sent to Detroit and dismantled by its British crew. Then the corporation was to manufacture the two pilot guns, complete in all respects except for the carriage, from the new drawings when they were approved.

For the drawings and the two guns, the contractor was originally to receive $66,000, but this amount was raised by three supplements. The first called for drawings for gun sight and loader cover and the manufacture of two of each. The second ordered that detailed design drawings be made on tracing linen. And the third specified preparation and publication of 100 copies of "Notes on Materiel" for the 40mm gun. The final total was to be $87,223.

This contractor was to be supplied with the barrels for these two guns, purchased by the Government from the Otis-Fensom Elevator Company, of Hamilton, Ontario, Canada. These were to be sent to

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33. No file number. Signed: W. E. Yocum (Mr. Yocum's file)
34. No. W-374-ORD-1170.

Watervliet Arsenal for rifling with a uniform twist of one turn in 30 calibers. Watervliet was then to send these to Chrysler. (35)

A few days after that contract had been given, another, for the carriages, (36) was given to the Firestone Tire and Rubber Company to do a comparable job on drawings for the carriage and to make two complete ones. This contractor was to translate all metric measurements into inches, convert all threads to American limited practice, work out tolerances according to a chart to be supplied by the contractor, change gear shapes and forms to American limited practice, and prepare and complete all tracings in accordance with Drafting Room Regulations of the Ordnance Department. The cost of this work was estimated at $69,960.

While these contracts were under way, studies were being conducted by the Chrysler Corporation (37) of the equipment necessary for making the Bofors 40mm gun at a rate of 500 a month. It was believed that this number would fill the needs of the British and of our Army and Navy. Carriages could be completed at a comparable rate, for the Navy would require a different type and would order its own. (38)

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35. Two memos, 4 Feb 1941, no file number, from H. L. McCormick, engr., to Brig Gen G. M. Barnes, in W. E. Yocum's file.
36. Contract No. W-303-CRD-917, dated 26 March 1941.
37. According to the Chrysler Corporation's ordnance manufacturing history, now in the official files of the War Dept. but unnumbered, "This work was accomplished in three months time, resulting in a gun with 5472 parts, including the carriage,..." That history was incorrect in assuming that this gun's 120 rounds a minute "is considerable improvement over that of the original gun," for the rate of fire of the original Bofors was 120.
38. Memo of 12 Feb 1941, from Brig Gen Earl McFarland, Asst to Chief of Ordnance, to Maj Gen J. A. Green, Chief of Coast Artillery, no file number. In personal file of W. E. Yocum.

The Chrysler Corporation had had considerable experience during World War I in the manufacture of ordnance materiel, operating then as the Chalmers-Maxwell organization, and further planning experience during the "educational orders" period of American industrial preparedness. Also, the corporation had completed, in August, 1940, a thorough study of the 37mm M4 gun, as made by Colt and had submitted a quantity production price to the War Department. (39) Nevertheless, the two pilot guns had to be manufactured by toolroom methods. Full scale production, when and if it should come, would necessitate full application of those principles of manufacture which have typified American industry. Chrysler's studies were, therefore, a sizeable part of the immense task of regearing our war machine which had passed through slack years; and were to result in the production, not of a bare 500 guns per month but a steady average of more than three times that many.

Before that production could be attained, much had to be done. On 16 April 1941, the United States Navy filed with the Chrysler Corporation a Letter of Intent (40) which the corporation signed five days later on 21 April. That letter gave the contractor full authority to proceed not only with the costly process of preparing plans for large production but also to lay out and build the plant and obtain the necessary equipment. The contractor did start work, as directed, on construction of the facilities to build the 40mm gun, although the

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39. Memorandum O.O. 472.1/156, 30 August 1940.
40. As noted in contract DA-NOrd (F)-1004.

formal contract which was to reimburse the company for its outlays, to the extent of $10,000,000, was not prepared until November of that year (41) and the supplement which was to add $6,293,731 was not signed until 27 February 1942. (42)

Here we see an anomalous situation which pointed up, with a sixteen million-dollar emphasis, the cooperation between the Army and the Navy. The manufacturer whose major production was to go to the Army with only a minor part to the Navy, was supplied with the necessary plant at Navy expense!

For the manufacture of the carriages, the Firestone Tire and Rubber Company was somewhat better prepared, in knowledge of intent at least, than was Chrysler for making the guns. The Defense Supplies Corporation, under the authority vested in it by the President for carrying out a part of the National Defense Program, had ordered 1,000 Bofors 40mm gun carriages from Firestone under a Letter of Intent 14 March 1941. There was no necessity for a new plant, though as time went on certain machine tools had to be added under the spur of further Government orders. Also, as subcontractors, Firestone Tire had the Marion Steam Shovel Company, with its wide experience in the art of welding which was to play a big part in the manufacture of the carriages, and the Truscon Steel Company, which would assure a satisfactory source of steel. Firestone, itself, was familiar with the mobile end of the work, including the gearing. (43)

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41. Contract: DA-NOrd (F)-1004. (This contract bears also, appended: "Lend-Lease Req. No. U.K.222) Given under authority of Section 8(b) of the Act of 28 June 1940 (Public No. 671, 76th Congress, 3rd Session) entitled "An Act to Expedite National Defense, and for other Purposes."
42. Ibid, Supplement No. 1.
43. Memo: H. L. McCormick, Engr. to Gen Barnes, 10 Feb 1941 in Yocum's file.

In June, a formal contract (44) was placed by the War Department with Firestone for the manufacture of 2,236 Bofors 40mm gun carriages, and incorporated these 1,000 carriages. (45) The estimated cost of this project was put at $17,888,000, exclusive of the contractor's fixed fee which was to be $1,073,280. Deliveries were to begin with 25 in October, 100 in November, and shortly hit a high of 300 per month for several months running.

This schedule was not met, for first deliveries were not made until February 1942.

In June, 1941, the procurement negotiations which had the Bofors 40mm AA gun in hand reached a climax. Previously, plans to make this gun for the use of our armed forces rested on the relatively insecure foundation of Britain's willingness for us to copy their gun. No license had yet been obtained from the originator, Aktiebolaget Bofors; and there is no evidence that our manufacture of Bofors 40mm AA guns for our own use, if it came to that after supplying Britain, would not have laid this Government, and Britain as well, open to damage suits by Bofors. On the other hand, correspondence indicates that all those involved seemed to assume without question that the license arrangement initiated in February by the Navy would be consummated; and in the absence of that license did not hesitate to move forward without any written official word to proceed. The timing of the National Defense Program did not permit

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44. No. W 303 Ord-952/DA W 303 Ord-8.
45. Ibid.

of delay in making the superior 40mm gun that might have been adopted two years previously and put in production almost concurrent with the beginning of the war in Europe.

In June came the long-expected Navy contract with Aktiebolaget Bofors which was to serve both the Army and the Navy. (46) Under this contract, the Bofors 40mm AA gun might be made for the American services as follows: Water-cooled for the Navy; twin mounts for the Navy; air-cooled for the Army; field carriages, under U. S. Patent 2,103,670, for the Army; and ammunition. June, 1941, also saw the signing of the contract for 2,236 gun carriages from Firestone, (47) another with Chrysler for 2,236 gun mechanisms (48) and a third with Otis-Fensom of Canada, for 4,472 gun barrels. (49) These were the first actual contracts covering quantity American production of this materiel. Closely on the heels of this action, the two pilot 40mm AA guns made by Chrysler and assembled by Firestone on Firestone's carriages, were delivered at Aberdeen Proving Ground late in June.

Plans were made for proof-testing these two guns and their carriages on the second of July. On the whole, the guns and the carriages performed excellently considering that these were the first of their kind, but both showed certain weaknesses and both failed in minor points of design. (50)

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46. No. N557s-2, dated 21 June 1941.
47. No. W303 Ord-952/DA W Ord-8.
48. Production order numbers 1484 and 1485.
49. No. DA-W-374-Ord-5 and W-374-Ord-1141, dated 12 June 1941.
50. Ord. Program No. 5444: Third Report, Supplement to Third Report, and Sixth Report.

After the first 17 rounds were fired from gun No. 1, the breech mechanism was disassembled. A slight upset of metal was observed on the breech block at the point which delivers the ejecting blow to the extractors, and another upsettage on the firing pin lever. After simple honing of the burrs, no further upset occurred in firing over 1,000 rounds.

Seven rounds of proof ammunition were fired from gun No. 2, after which a burst of rapid fire was attempted. The loading mechanism jammed after 14 such rounds due to the backing out of a taper pin on the feed roller control shaft. When it was found that the pawl in the right side of the loading tray was scored by contact with the control lever, the scoring was smoothed up and another pin was installed. Another burst of rapid fire was interrupted by functional failure of the feed roller controls. Examination showed that the trouble lay in the use, through an error on the part of a toolmaker, of a bolt in the roller control shaft support bracket where a reamed dowel is called for in the drawings. Several other minor faults were found and corrected, and recommendations were made for their permanent change.

The principal failures in the pilot carriages, M1, for the 40mm AA M1 gun may be attributed to its British design which "is not sufficiently rugged to stand the severe conditions of operation to which similar materiel has been subjected in passing Proving Ground tests."(51)

Most of the recommendations in those reports for refinements of design were approved and ordered by change orders without affecting the M1 classification of the carriage. But in October, 1941, certain important differences between the British and the American made carriages

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51. Ibid, Supplement to Third Report.

were pointed out and the recommendation was made that the classification of the carriage be accordingly changed to M2, while the carriage for the British and other defense projects retained the classification M1. (52) These differences came about in our design of an American type drawbar and lunette, adoption of electric brakes on the United States carriage, and the standardization of remote control system M5, which is designed for 60-cycle power, instead of the British remote control system M3 for use with 50-cycle power.

One other important decision had still to be made: Whether the twist of the gun tube rifling should be uniform, one turn in 30 calibers, or accelerated as was the original Bofors and its British counterpart, one turn in 45 calibers at the breech and increasing to one turn in 30 calibers at the muzzle. It will be remembered that the two pilot guns had been ordered for uniform twist, or one turn in 30 throughout the length of the barrel. Furthermore, all comment and correspondence prior to the manufacture of these two expressed the belief that this uniform twist would be more satisfactory for us and that it would be impossible "with present equipment" to rifle barrels with an increasing twist at Watervliet Arsenal (where the tubes for the pilot guns were finished).

Rifling comparison tests were considered necessary as early as February, 1941, (53) but an order that they be made was not given

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52. O.C.M. Item 17442 dated 21 Nov 1941. M2 classification approved in O.C.M. Item No. 17499 dated 4 Dec 1941.
53. Memo dated 11 Feb 1941 from Brig Gen R. H. Somers. Yocum's file.

until October, (54) and they were not made until December, 1941, and April, 1942.

In ordering the tests, Brig. Gen. Barnes noted that one of our pilot tubes--No. 1--with a uniform twist should be test-fired in comparison with a new tube rifled with increasing twist that was shortly to arrive at Aberdeen. This latter tube was, doubtless, the newer tube of two complete guns and equipment donated without cost to the War Department by the British in accordance with a letter from Maj. Gen. D. H. Pratt, of the British Military Mission. (55)

It was concluded from these tests (56) that the tube with the increasing twist had an accuracy life of approximately 6,000 service rounds while that of the American tube with uniform twist was 4,200 full service rounds. With the American tube, the following differences from the original type were noted: The yaw of projectiles was larger and very erratic; shearing of the rotating bands of projectiles was greater; bourrelets of projectiles exhibited more pronounced traces of engraving from lands; more initial strain was thrown on both gun and projectile; etc. The test report made the recommendation that

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54. Letter O.O. 472.93/4101 dated 7 Oct 1941. The need for an early decision was emphasized as we were rapidly approaching quantity production.
55. Letter O.O. 350.05/156 dated 8 Feb 1941 offered "1. The complete 40mm Bofors gun and carriage with fire control equipment, the Kerrison Prediction, etc., that is now in the hands of the U.S. Ordnance Dept. 2. A duplicate equipment as in (1) above..."
56. O.O. 5444 dated 31 July 1942.

tubes for American 40mm AA guns be "continued to be manufactured with the increased twist rifling of one turn in 45 calibers to one turn in 30 calibers." (57)

No formal order was necessary to carry out this recommendation, and tubes for these guns later made in this country were rifled accordingly.

The gun we had at last refined and fully adopted as our standard after more than five years of negotiations, fires a 1.96-pound shell to a vertical range of 4.3 miles. (58) Aiming can be accomplished with great rapidity, fire usually being in short bursts of four or five rounds. If the barrel overheats due to the high rate of fire of 120 to 140 rounds per minute, the overheated barrel can be removed and a new one inserted in approximately two minutes.

The complete gun mechanism consists of the barrel assembly, the recoil cyclinder, the breech casing, the breech mechanism, and the automatic loading assembly. The tube, of forged alloy steel, is threaded at its muzzle for the attachment of the flash hider, a bell-shaped muzzle piece which protects the crew from the blinding flash of firing. The rectangular breech-casing forms a chamber for the breech ring, breechlock, and loading mechanism. It is supported in the

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57. The only other recommendation in this report suggested that "Similar comparative tests be performed on other caliber AA gun tubes using fixed ammunition to determine whether the increasing twist rifling materially affects the accuracy life. (Refer to Appendix C--Ballistic Research Laboratory Memo Report No. 57.)" The Bofors had been a superior gun for years, and the probability that some part of its excellence was due to its rifling should have been suspected long before!

58. Catalogue of standard ordnance items: Volume on Aircraft Armament.

carriage by means of flanged trunnions at the sides of the casing. A breechblock of the sliding vertical type, concave on its tope to form a loading trough when open, is seated in a slot in the breech ring. The breechblock closes automatically when a round is inserted in the bore and opens automatically during the recoil, at which time the empty cartridge case is ejected.

A recuperator spring is assembled near and around the breech end of the tube. The hydrospring recoil system is housed in a cylinder underneath the recuperator spring and is held in position by a supporting bracket secured to the breech casing. The automatic loading mechanism feeds cartridges one by one into a loading tray from which they are pushed into the chamber by a mechanically operated rammer. A hand-operating device is used for setting the mechanism for loading the first round or for removing the cartridge.

The frame or chassis of the M2 carriage (59) is a circular-shaped structure with longitudinal girders front and rear, and two transverse, hinged outriggers. The top carriage rotates on ball bearings about a vertical axis, and carries the loading platform and operating equipment. When going into action, the gun is lowered to firing position by swinging out the outriggers and rotating the axle trees to lift the wheels off the ground. At the ends of the girders and the outriggers are adjustable jacks for leveling the entire gun on uneven ground. The spring suspension is arranged according to the Bofors parallelogram system, so that wheels spring independently of each other. Electric

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59. Ibid.

brakes, operated from the prime mover, are furnished on all four wheels, and these may be operated if there is an accidental separation of the carriage from the prime mover. Handbrakes are also supplied.

On this carriage are two spring type equilibrators--to counterbalance the tube--housed in tubular casings held in a trunnion. They are located under the gun and between the gun trunnion frames. The elevating and traversing mechanisms are provided with individual electro-oil drives operated by 0.6 horsepower electric motors. In the event of failure of the remote control system, power plant, or director, the direct sighting system is used. The firing mechanism can be operated either by front or rear foot pedals interconnected and linked to the firing lever. The gun can, of course, be placed on safety, and can be adjusted for single shot or automatic fire.

The carriage includes the above-mentioned frame, or chassis, and a lower chassis with wheels, but not the gun and automatic mechanism. It weighs approximately 5,000 pounds, and is constructed principally of weldments, castings, stampings, forgings, and plates.

The sighting and fire control equipment consist (late 1943) of Bofors direct fire sights on the carriage; and, off the carriage, director M5A1, remote control system M10, generating unit M10, and gunner's quadrant M1 or M1918.

It should be interesting here to compare certain of these details with those, given in another chapter, on the 37mm AA gun which

the 40mm AA M1 gun superseded. Of interest also is the difference, at least in the size of the projectiles, between the Americanized gun and the original Bofors described briefly at the beginning of this chapter.

At this point there was still some question as to the complete interchangeability of parts of the guns and carriages. It will be remembered that the air-cooled M1 gun and the M2 carriage were standard for the United States Army. For the British, the M1 gun and the M1 carriage were to be made, this carriage being less rugged than the American M2. That first order for 2,256 complete guns and carriages, mentioned above, was actually for the British on a Lend-Lease basis. The record shows, however, that this order was cut back to 1,500 of the materiel, and these were completed though the British got only 1,392 of them. The table shows that this 1,500 is the total of our M1 carriage production.

Gun mechanisms, as made by Chrysler, were also supplied to the British for mounting on ships on mounts of their own make. The United States Navy, having financed Chrysler's new 40mm plant, has taken about 15 percent of that corporation's production of gun mechanisms, these being water-cooled. They are installed on Navy twin mounts, and sometimes eight of them are grouped into octuple warship mounts.

At the outset, the question came up as to whose drawings for the gun mechanism should be used: The Navy's which were made by York Safe and Lock, or the Army's which were made by Chrysler. Some Navy men said that York's, which were the last to be ready, should be used

because they had been Navy-checked. Rear Admiral W. H. P. Blandy settled that point by ordering that all interchangeable parts of gun mechanisms be made according to Chrysler's drawings. (60)

Typical modern American industrial methods and shortcuts are employed at the Chrysler and Firestone plants, and these were to be the pattern to guide other plants that were, later on, to make both the guns and the carriages. Consequently, there was a great saving of man-hours, machinery, and materials. An unnamed British Officer from Sheffield, England, after visiting the Chrysler Arsenal said that its production was double that of the combined production from one Canadian and four English plants. (61) That officer stated that British plants take from 260 to 340 hours to assemble one gun, whereas the same work is done at Chrysler's Lynch Road Plant in 14 hours! The difference, he observed, was doubtless due to the fact that precision manufacture in this country makes hand fitting unnecessary.

Until manufacture of the gun began in America, it was produced abroad essentially by toolroom methods--as were the two pilot guns and carriages we made. However, our manufacturers speeded up production by welding, by flame cutting, by minimizing manual effort in assembly through use of fixture such as arbors and yokes, by splitting

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60. Letter S74/Nos 8709 dated 14 Nov 1941, to Gen Barnes: "I have directed that all Chrysler Bofors gun parts common to both Army and Navy guns shall be made in accordance with Army drawings and inspected with Watervliet's gages where practicable. The result will be a small percentage (about 10 percent) of parts which will not be interchangeable between Chrysler naval guns and York naval guns, but...there is only a remote probability of trouble on that score."

61 History of the Chrysler Ordnance effort, in War Dept. files.

the milling on the breech into seven set-ups instead of one, by standardizing a large variety of fillets to obviate numerous tool changes, and by similar American practices.

Seemingly, hundreds of Bofors parts were originally designed to be done the most difficult way. (62) Bar stock was specified for complex pieces, even though 90 percent of the metal was later machined away. As an example, the flash hider was originally machined from a solid steel forging weighing 40 pounds, though the finished bell-mouthed assembly weighs 10 pounds. To simplify this, the engineers tried pierced forgings. Difficult machining was still necessary, and complicated fixtures and critical machine tools were required. A relatively simple swaging operation, in which one end of a tube is swaged down by a die ring and the other is flared by a punch, was then tried and found to be successful from the first. With this and other simplifications of the design of the flash hider, many tons of steel are saved each month, six machines of a critical nature could be reassigned to other work, and nine machines, otherwise necessary when gun quotas were increased, were not ordered. (63) Each month, something like 4,893 man-hours are saved by Chrysler alone in the manufacture of this single part.

For all the delays in the history of the procurement of this weapon, movement was fast following the signing of the contract and the manufacture and testing of the two pilot guns. This equipment had not before been manufactured on a mass production basis. Hence

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62. Armament Section of American Machinist, April 29, 1943.
63. Ibid.

the problems involved were numerous, particularly in connection with the gun mechanism and the oil gears used in the remote control system. Facilities possessing the required equipment were not available, and this necessitated a very extensive retooling program involving the purchase of large quantities of machine tools such as profiling, honing, and rifling machines, and thread milling equipment not used to any appreciable extent in commercial manufacturing processes. The procurement of nearly all of this equipment had to be initiated under low priorities which existed at the time the project was started.

Delivery of the first 25 guns had been scheduled for October, 1941, but because of these difficulties, the first delivery of 19 guns was made in February, 1942. Production of gun mechanisms began 15 December, 1941; final assembly was begun on 5 January; and the first mechanism was completed 5 February, 1942. (64)

Once started, Chrysler rapidly speeded up production, from 19 in February to 134, 379, 500, 692, 840, in the next five months, and onward to a peak of 1,600 in December, 1942. At the same time, the corporation's production of gun barrels began in March with an output of four, rose rapidly to 1,492 in June, dropped to around a thousand for three months, then jumped up to 3,336 for November, and hit a new high of 4,199 in January, 1943. (65) Stock for the barrels was supplied by Atlas Steel, Timken Ordnance Plant, and Watervliet Arsenal

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64. Chrysler's Ordnance Effort History, Ordnance Historical File.
65. Basic history, Chrysler Ordnance effort. This differs from the table because the latter shows Ordnance Department acceptances.

in the form of rough forged tubes, pierced upset tubes, and centrifugal cast tubes, by the three facilities respectively. (66)

Chrysler continued as the prime producer of gun mechanisms and of tube assemblies throughout the Army procurement program, but because of the Navy's first call on this contractor, and because of the stepping up of the War effort after the attack on Pearl Harbor, Otis-Fensom of Canada, continued to supply large numbers of finished tube assemblies.

A much larger production of 40mm AA guns was needed when we entered the war for, besides the needs of our military forces, there was also the necessity for protecting many of our cities against possible air attacks. Therefore the Pontiac Motors Division of General Motors was selected as a contractor to make tube assemblies and finished gun mechanisms for shipment to the carriage manufacturers for complete assembly.

Pontiac needed no such plant expansion as that at Chrysler, though some new machinery had to be ordered. The ground-work of experience had already been laid at Chrysler, and Pontiac would never be considered for production of such quantities as Chrysler had scheduled for both the Army and the Navy. Pontiac's plants, north and west of Pontiac, Michigan, total 3,400,000 square feet of floor area, of which only about a quarter of a million square feet were allocated to the 40mm Bofors gun. When the plant was selected, the planning department, with a wide experience in the manufacture of

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66. See chapter on manufacturing and development. (To be written.)

automobiles, was still intact; and there was on hand a capable engineering department as well as an executive staff which knew the industry from the ground up. That this organization functioned efficiently is shown by the fact that the first gun mechanisms were delivered in October, 1942, or just nine months after the first order had been given in January, 1942, while the first 425 tube assemblies were accepted in November, 1942.

The Firestone Tire and Rubber Company had had no previous experience in the manufacture of machinery to the close tolerances and under such special requirements as those of the 40mm AA gun carriages M1 and M2. But the company was well staffed with men who had long experience in the automobile industry's demands, and problems in the manufacture of the carriages were overcome as they arose. First delivery of completed materiel was made by this contractor in June, 1942, and by August the company was turning out carriages at the rate of 35 per day, and was working seven days a week. The production schedule was heavy, and continued so throughout the Army's procurement program which tapered off rapidly early in 1944. Through 31 March, 1944, this contractor's production totaled 18,521 carriages.

How well the Firestone company took its new job in hand is shown by the fact that shortly after its first contract was awarded, the contractor worked out in August, 1942, a new spring action for the carriage. Called the Air Spring Suspension, this device is a major departure from the original Bofors individual wheel springs. It will

be discussed later in detail.

Before Pearl Harbor, it was realized that additional facilities for the manufacture of carriages would be needed. In October, 1941, the first order for 750 carriages was given to The Koppers Company, whose commercial business was medium size forgings, bronze and iron castings, welded steel products, and machinery and weldments. It was reported (67) that this contractor's facilities and the original contract (68) provided for purchase of machine tools for a production of 600 of the carriages per month, but this quantity was not adhered to. A year after the first order was given, this contractor finished its first 35 carriages. Additional orders were given so that by February, when this contractor's schedule was completed, the company had made a total of 2,270 carriages.

Another contractor for manufacturing the 40mm carriage, the J. I. Case Company, came onto the scene in March, 1942, with a contract for 2,000 carriages. First deliveries were scheduled for September and were actually made in October. At the end of 1943, the company had completed its schedule, having made only 1,414 carriages due to cut-backs from the original order. The company was, however, well organized and capable, and there is no record of any appreciable delays or upsets in its production schedule. J. I. Case is a manufacturer of a wide variety of farm machinery and of tractors.

It has already been noted that the first two prime contractors, Chrysler and Firestone, who had to translate the foreign drawings and

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67. Production Follow-Up Report No. C1(C1) dated 21 May 1942.
68. W-670-Ord-2076.

start production from scratch, performed a commendable job. Nevertheless, they had their troubles. And so did the other prime contractors for tubes and mechanisms, and for carriages. There was often an imbalance between between production not only of the major components but also of the parts and equipment made by sub-contractors. (69) At an early stage of production, Firestone went ahead of Chrysler in production and the result was a surplus of carriages. To take up some of this surplus, a project for converting some carriages into twin 20mm mounts was initiated.

In December, 1942, Firestone could not make its year-end quota of complete materiel assemblies largely because of lack of gun mechanisms which had not been delivered by Chrysler. This was due, according to a letter from an Ordnance inspector, (70) to several circumstances. First, Chrysler had had considerable trouble producing and assembling gun mechanisms mainly because of welding defects. Secondly, 100 gun mechanisms which had been sent to Erie Proving Ground for proofing had not been forwarded for assembly on carriages. And, finally, there was the manpower problem: Many men had been drafted from the Firestone plant and, in addition, there had been three walkouts of men from the assembly floor. A previous letter dated 10 December from the same inspector, stated that both Firestone and J. I. Case had shut down their assembly lines "on different occasions because of a lack of guns."

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69. Production Follow-up Reports for the facilities names.
70. Letter of 28 Dec, 1942, from 1st Lt Paul N. Stanton to Col G. M. Taylor.

These delays were not unduly long or serious. Nor were others relating to slow delivery of minor components of guns and carriages. There is constant mention of them in correspondence of the early days but no evidence that important delays resulted at any time. In the building of original plants and the expansion of others for increased production, machine tools and gages were often delayed but in every case noted in the Production Follow-up Reports, comment is made that such delays "will not hold up schedules." The inference is plain, though it cannot be documented, that the primary cause of any imbalance, slow production, and delivery delays was that American manufacturers had to gain the "know-how" in what amounted practically to a new industry. And that is but a reflection of the many years the United States people ignored the war-like thought of certain other nations.

American use of the Bofors type 40mm gun indicated that the traversing mechanism of the carriage operated too slowly while the gun was tracking a plane, and steps were taken to increase its speed. When tracking a plane manually, the gun on both the M1 and the M2 carriages swung through an arc of 10° 18' with one turn of the handwheel, this speed having been worked into the design while planes were still relatively slow, back in the nineteen-thirties. Hence, in March, 1943, after war had speeded planes considerably, a traversing gear assembly which swung the gun 17°08'35" with one turn of the handwheel was designed, and the carriage with this improvement was designated

M2E3. The Ordnance Technical Committee recommended (71) that this type of traversing gear assembly be incorporated in all 40mm gun carriages M1 and M2 then in existence and to be manufactured in the future; and that the classifications be changed to carriage M1A1 and carriage M2A1 respectively. The reclassification of the M1 was simply a formality, as we had by that time completed all orders for the British, and for ourselves were using the M2 alone. The recommendations were approved in August, (72) though it appears from a handwritten note in the 40mm carriage file that Firestone actually began making the new carriages on 20 July 1943.

A message that undoubtedly marks the first step toward a new use of the 40mm Bofors gun and the standardization of a new carriage, or mount, M3, is contained in teletype, dated 1 December 1942, from the Cleveland Ordnance District to the Ordnance Department. This message said that the Navy required, within the next few days, 10 top carriages less fire control equipment, and that the Navy would require 50 per month thereafter until a total of 220 had been delivered. The top carriages to be furnished were to be complete, including pedestal, traversing bearing, breech mechanism, and gun, but were to have no special parts. Production Order C-5531 and funds to the amount of $500,000, under procurement authority order 60314 P130 A1005-25 were forwarded to cover issuance of Letter Purchase Order until sufficient data were available on which to base a contract.

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71. O.C.M. Item 21098.
72. O.C.M. Item 21345 dated 19 August 1943.

Supplement 13, dated 3 December 1942, to Firestone's basic carriage contract (73) then called for "815 Mounts, Gun, 40mm, M3," though there was no recorded authority for this M3 classification. Later, on 14 December, an entry was made on a file card in the Official Nomenclature Record to the effect that M3 was the designation adopted by the Navy for the top carriage of the 40mm gun carriage M2 for mounting on shipboard, and this was verified in a teletype from the Cleveland Ordnance District 16 December 1942.

By diverting materials and equipment from existing orders, Firestone was able to make first deliveries within seven days, a record in view of the fact that the company was making similar materiel.

Supplement 14, which was addressed to Firestone 26 February, 1943, ties to the above-mentioned emergency order for 10 carriages for the Navy in two ways: It stated that the 815 mounts it called for included the 220 previously allocated; and secondly, it gave the same description of the amount required.

What use the Navy would have for this new mount M3 was said to be a secret when the first emergency order for ten came through, (74) and there is no written record available to show that this use was ever explained. Oral opinions of officers in the Artillery Branch of the O.C.O. and production tabulations, however, indicate that these were desired for use against submarines as well as against low-flying aircraft, the mounts to be installed on smaller craft such as LST's, landing barges, and the like.

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73. W-303-Ord-952, DA-W-303-Ord-8.
74. Memo, 26 Dec 1942, from Col G. M. Taylor.

The Navy had been taking a sizeable production of these mounts for some months when the Army also decided to use them. It is supposed that these latter were for mounting on Army transports and supply ships, primarily as anti-submarine guns, though here again the record is lacking. At any rate, the Army procured, out of a total production of 4,784 through March 1944, the relatively small number of 159. The remainder went to the Navy.

In their constant search for methods and designs that would utilize the Bofors 40mm gun to the fullest extent and for all purposes in which it should be effective. Ordnance engineers, in September, 1942, conceived its use on a self-propelled vehicle to accompany mobile units other than armored forces. The recommendation was made (75) that the proposed carriage have the following characteristics: 1, carry twin guns; 2, carry a crew of five; 3, carry ammunition for one minute of automatic fire; 4, that gun and fire control be operable while carriage is in motion; 5, have a cruising range of 150 to 200 miles; 6, have a gun elevation of 90° or more; 7, carry full automatic fire control except range setting; and 8, carry a radio receiver. It was further recommended that the designation be Twin 40mm Gun Motor Carriage T65, and that two pilots be made. These recommendations were approved, (76) and manufacture was begun.

To adapt the 40mm gun M1 to twin mounting, a new gun mount, T12, was worked out. (77) This consisted of a left-hand gun T3 and a

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75. O.C.M. Item 19046 of 2 Sept 1942.
76. O.C.M. Item 19133 of 31 Oct 1942.
77. O.C.M. Item 20297 of 29 April 1943.

right-hand gun T2. T3 is essentially a standard 40mm gun M1 slightly modified so the extractor lever could be installed on the bottom side of the gun. The extractor spindle was modified to permit installation from the left side. The right gun, T2, is similar to the Navy 40mm gun, right hand. It differs from the standard 40mm gun, M1, in the following respects: It has right-hand feed features; its hand-operating lever is on the right side; the firing mechanism is on the right side of the inner breech casing; right-hand frame of the top carriage was modified; the extractor lever is on the bottom of the gun; the breech-closing spring and the outer crankshaft closing spring are located on the side opposite that of the M1 gun; the breech ring lock is located on the right side; and the elevating scale is on the right side. Modifications for improved functioning were made, and the mount designation changed to T12E1; and the mount was scheduled to be standardized as Twin 40mm gun mount M4 early in May 1944. (78)

The chassis of several different light tanks were tried in the various tests of this design, each using the mount T12 or the T12E1, and the classification of the motor carriage was changed to T65E1. It is reported that this carriage is about to be classified Twin 40mm gun motor carriage M19, (79) but it is still under service test in May, 1944, at Camp Davis, N. C., (80) and that establishment's report is not yet in.

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78. According to Official Nomenclature Record.
79. Ibid.
80. O.C.O., Tech. Div., Consolidated Reports on Research and Development Projects, Period of 10 Mar - 10 April 1944.

The 40mm AA gun M1 was a logical contender for honors as an airborne weapon. It was small enough to be loaded into a plane for transport to points inaccessible by land or water transport, and packed a powerful enough punch for effective protection of isolated airdromes.

The airborne mount which was to become mount M5, started off in mid-1942 as experimental mount T8. T8 resulted from a request from Headquarters, Anti-Aircraft Artillery Command, (81) for a 40mm gun mount that could be loaded in a standard Army transport plane. In August, 1942, development of the project and manufacture of pilot models was recommended. (82) This recommendation was approved in October (83) and work proceeded on the pilot. Duly completed, the pilot was tested at Aberdeen and a report rendered in November. (84)

This report described the mount as the top carriage and fire control equipment of the 40mm Gun Carriage M2 secured to a fabricated chassis, and with outriggers to give stability. The side and rear outriggers are detachable while the front one is welded to the base

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81. Letter O.O. 472.93/253.
82. O.C.M. Item 18883 dated 28 Aug 1942. Item states: "The investigation in regard to machine guns has been completed and consideration is now being given to the 20mm and 40mm calibers. 1st indorsement states, in effect,...that the 40mm Gun Carriage M2, if stripped of wheels and axles would still be stable, but that to handle in and out of a plane, a lighter mount of new design would be more satisfactory."
83. O.C.M. Item 19024 of 7 Oct 1942.
84. "Notes on Materiel," 40mm AA Gun Carriage, T8 (Airborne), program 5444.

of the mount and has a stationery pintle attached to its front end for towing. Screwjacks on all outriggers permit leveling the gun in firing; and raise or lower mount when removing or installing wheels or outriggers. Two wheels with mechanical brakes and mounted on removable brackets, are provided for moving the mount short distances on land. Three shields, to protect the crew from small arms fire, are designed for field installation. To reduce the over-all dimensions for plane transportation, the gun barrel, side shields, and the three detachable outriggers must be removed and loaded separately. Operators' seats are swung in by means of the pivoting posts, and the outside footrests are removed and placed in carrying positions. The handwheels are carried in normal traveling position on the carriage platform.

Almost from the beginning of this development, there was a considerable difference of opinion as to the utility of mount T8. Repeatedly, it was emphasized that the mount would have no value whatsoever in those places where other mounts and carriages could be used, that its sole value was as a weapon to be transported to points that are inaccessible except by air. And, because of the weight and the bulk involved, discussion went back and forth as to the models of the various pieces of fire control equipment that should be carried with it. A further objection was that the mount was hard to handle in and out of a plane.

These various comments and criticisms led to an order in July, 1943, for the manufacture of 18 of these mounts T8 for test at several locations. These were to incorporate changes recommended by

Aberdeen Proving Ground, and were to be designated T8E1 and T8E2, the difference in the designations indicating use of different oil gears. This project was approved in August. (85)

Earlier in August, the recommendation had been made that the T8E1, modified to mount computing sight M7, be approved as the required and adopted type and a standard item under the designation of 40mm Gun Mount M5, but there was still so much discussion of details and "partial non-concurrence" that the situation was anything but clear. Hence, in December, 1943, it was necessary to prepare an O.C.M. Item (86) having as its purpose, as frankly stated in the title, the "Clarification of status" of the mount's classification. This stated that the classification was M5 and that the procurement of 200 of them had been initiated. (87) These were manufactured on schedule and delivered during December 1943.

The history of the Bofors type 40mm materiel in American hands is replete with evidence of the desire to improve on this superior weapon not only to increase its efficiency but also to widen its range of usefulness.

The air spring suspension of the 40mm carriage, invented by the Firestone Tire and Rubber Company before production of the gun or the carriage had gotten under way, is an outstanding case in point. Firestone suggested this to the Ordnance Department in a

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85. O.C.M. Item 21346 of 19 Aug 1943.
86. O.C.M. Item 22532 of 30 Dec 1943.
87. Contract W-33-019 Ord 416 of 11 Oct 1943.

letter of 29 August 1941 (88) in which the advantages were stated as follows:

1. Elimination of manual effort to change carriage from mobile to firing position.

2. Mechanical simplicity; hence, considerably reduced first cost and maintenance.

3. Increased reliability and durability in field service.

4. Better riding.

5. Reduction in requirements for vital materials, steel alloy, etc.

The project was approved on 10 September 1941, and one carriage was to be built under the designation M1E1. (89) That classification was later changed to T2, (90) the carriage was built, and tests were conducted on 21 April and 17 May 1942. An abstract of the test report (91) will give the basic details of the design.

The air spring suspension consists of a rubberized fabric bellows housed in a bell-shaped cylinder, four of these being mounted, one on each wheel. A shaft through the center of each spring links the cylindrical unit to the bottom of the kingpin. In addition, two V-shaped arms connect the kingpin and the center frame section. Air, fed to the system through a central valve, inflates the assembly until the pressure in the bellows is sufficient to carry the weight of the mount. Each spring operates independently of the others while traveling, and their central shafts move in and out of the cylindrical housing depending on the force acting on the wheel and the kingpin

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88. O.O. 472.93/3491.
89. O.C.M. Item 17222.
90. O.O. 472.91/1905, dated 20 Feb 1942.
91. Aberdeen P.G., report on Ord. Program 5444, dated 2 Sept 1942.

and, with the accordion-like action of the bellows, the air spring is compressed or expanded.

The tests found that the T2 carriage design is superior in serviceability, stability, and maneuverability; that it is practical and reliable over a variety of roads; that it permits greatly accelerated movement to and from traveling position in comparison with any other carriage previously tested; and that, during proof firing, no weaknesses were discovered.

Numerous minor changes, such as strengthening of welds and the like, were suggested, and when these had been made and further investigation of the design ordered, the classification was changed to T2E1. (92) In May, 1944, an order was being written for modifying T2E1 to T2E2 to include changes recommended in test reports. Procurement of 35 carriages, T2E2, was recommended for further test.

Production of the 40mm gun had not actually begun when, in May 1941, it was believed that it could be adapted to a half track chassis. (93) The necessary conversions were made, using the gun, M1, and the Kerrison Predictor on the half track chassis, T3. The project proved unsatisfactory, and was abandonded early in 1942.

One of the most costly failures recorded on all these experimental mount models was that chalked up by the T3. The conception of this design as an anti-torpedo boat mount by the United Shoe Machinery Corporation was excellent, and the development was recommended by the

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92. O.C.M. Item 22030, dated 22 Oct 1943.
93. O.C.M. Items 16801 and 16831 of May 1941.

Ordnance Technical Committee on 14 May 1942. (94) Some days later, a resume of the details of this development were given, and a price of $100,000 quoted for the first model. (95)

Experimental mount T3, for the 40mm gun M1, was to be a turret type gun mount on a pedestal base for mounting on a fixed emplacement. It was to have one gun, was to be covered with armor plate all around, was to have a crew of four; and it was to permit elevation of the gun from minus 10° to plus 90°. Obviously this mount would be useful against dive bombers as well as against torpedo boats.

The pilot mount T3 was made according to schedule, tested at Aberdeen, and reported upon under date of 12 December 1943. (96) The conclusions of that report are succinct: "1. The 40mm Gun Mount, T3, is unsatisfactory as an anti-torpedo boat and antiaircraft weapon, and as designed is unworthy of further test and development; 2. The gun mount is an unnecessarily complicated mechanism for the simple functions it performs." The main recommendation was that, if further development should be undertaken, the mount be redesigned rather than modified. The project was later canceled by O.C.M. Item 21940, on 28 October 1943.

Canceled at the same time was the project to develop 40mm Twin Gun Mount T6, which was conceived as a pedestal mount for anti-torpedo boat and antiaircraft use. It mounted two paired 40mm

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94. O.C.M. Item 18201.
95. O.O. 472.93/1068 dated 26 May 1942.
96. First Report on Development Test of Pilot 40mm Gun Mount, T3; Ordnance Program 5966.

automatic guns, T2 and T3, which are described elsewhere.

The Aetna Standard Engineering Company saw possibilities in the 40mm gun and started work toward adapting it to a tank mounting. The project was approved early in 1942 and their unit designated the T36.

Aetna's design envisioned conversion of a medium tank, M3, to carry one 40mm gun, M1, the tipping parts of the standard 40mm gun carriage, M2, and associated fire control equipment. This combination was designated 40mm gun mount, T4, in its specially designed turret which replaced the regular turret of the standard medium tank, M3.

The first report of tests of the pilot 40mm gun motor carriage, T36, was rendered in February 1943, and recommended numerous changes such as: better provisions for loading at all gun elevations; suitable deflector for ejected cases; the raising of the driver's compartment four inches; open sight range finer; and intercommunication system, etc. It recommended, further, that the T36 carriage be shipped to the Antiaircraft Board for their investigation of the advisability of further development. Opinion on this design was adverse and the development was finally discontinued. (97)

The half track personnel carrier, M3, was considered as a possible carriage for the 40mm gun in July 1942, and the project was begun with the design of adapter parts. (98) For this adaptation, the M1 gun and the rotating parts of the carriage, M2, with bottom

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97. O.M.M. Item 21297.
98. O.C.M. Item 18508 of 4 July 1942.

roller path and a suitable sub-base were used, this new combination making the 40mm gun mount, T5. The carriage on which the T5 was mounted was to be classified T54. Later, this was changed to T54E1 as modifications were made to lower the total height. After suitable trials, the entire project, including the gun mount, T5, and the motor carriage, T54E1, was suspended. (99)

Initiative was shown by a private company in the attempt to develop a twin mount for the 40mm gun on the same half track personnel carrier, M3, about the same time the development mentioned in the preceding paragraph got under way. The organization was the American Ordnance Company, and the mount they developed for this application, the gun mount T9, incorporated an over-and-under arrangement of two 40mm guns with an overhead equilibrator. (100)

This mount on the personnel carrier made a combination which was given the designation T68, and was completed and tested. Further development of the gun mount and of twin 40mm gun motor carriage T68 was terminated in a single Ordnance Committee action. (101)

A third conception of the use of the half track personnel carrier, M3, as a vehicle for mounting the 40mm gun was that which started in August, 1942, as the 40mm gun motor carriage T59. It was changed later to the T59E1, and then was suspended. (102) The gun mount used in this combination was designated the T7 and was identical with the gun mount, T5, except for the addition of remote control system, M5.

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99. O.C.M. Item 21298.
100. Memo, 20 Oct 1942, Carriage Section file No. 3, no file number.
101. O.C.M. Item 20878.
102. O.C.M. Items 19960, 19274, and 21298.

An attempt was made, beginning in February, 1943, (103) to make use of the caliber .50 machine gun mount, T5, as a mount for two 40mm automatic guns, M1. However, it was found that this machine gun mount was not sufficiently rigid to withstand the stress of firing the heavier guns, and the project was canceled four months later. (104)

A project for combining the usefulness of the 40mm gun and two caliber .50 machine guns on a single motor carriage was well under way in April, 1944, and the mojnt, T98, to carry these three guns, was under manufacture at Firestone. (105) This combination gun mount, T98, consists of the top carriage of the M2, mounting one 40mm gun, M1, and two caliber .50 machine guns, M2, heavy barrel, plus the computing sight, T63. The T98 gun mount is provided with a local control system consisting of drive controller, oil gear, and wiring set. Power for operating the gun mount using this local control system is received from the electrical system of the vehicle. The T98 gun mount will be installed on the combination gun motor carriage T81.

At this writing, (106) the story of the Americanized Bofors 40mm gun is incomplete. Notably lacking is a necessary analysis of total orders for the gun from American manufacturers for our own Army and Navy and for international aid, and the corresponding deliveries. There is, too, the matter of payment to Bofors for manufacturing rights

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103. O.C.M. Item 19795 of 25 Feb 1943.
104. O.C.M. Item 20347 of 6 May 1943.
105. O.C.O., Tech. Div. Consolidated report...10Mar--10 Apr 1944.
106. May, 1944.

which, to date, has not been cleared up. A few other minor details will be cleared as information regarding them can be obtained.

Standardization of certain of those experimental mounts and carriages mentioned in the preceding pages will doubtless come in time and be duly recorded. These models and those that have been discontinued, have been tested intensively to discover the full worth of all components of this materiel. In consequence, the United States now knows that its "naturalized" Bofors 40mm gun and carriage compose a unit that is superior in many ways to the originals from Sweden, England, and Holland. And even the originals were of a superior type!

End

PRODUCTION QUANTITIES,
GUN MECHANISM, 40mm M1
(Common Component)

Facility		First Orders	First Delivery	Prod. to 31 Dec.1943	Total Production	Schedule Completed
Chrysler	Date	5 June 1941	Feb. 1942	22,202	31 Mar.'44:	
	Quan.	2,236*	19		24,802	
Pontiac	Date	21 Jan. 1942	Oct. 1942			
	Quan.	1,500	2	4,169	?	4,900

*4472 Tube assemblies for these (2236) guns were procured from the Otis Fensom Co.

The Gun, 40mm, M1, was allocated to:	To Dec. 31, 1943
40mm Anti-Sub Gun, Mount M3, Army	54
40mm Anti-sub Gun, Mount M3, Navy	2,680
40mm Gun, Airborne, Mount M5	218
40mm AA Gun Carriage, M1, for British	1,392
40mm AA Gun carriage, M2, for U.S.	21,005
Proof facilities and development, M1	5
Miscellaneous diversions	28
Unallocated	989
Total produced to 31 Dec. 1943	26,371

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PRODUCTION OF CARRIAGE, GUN, 40mm, M1, M2, M2A1

Facility		First Order	First Del.	Prod. to 31 Dec. '43	Total Prod.	Schedule Completed
Firestone	Date	24 June '41	June '42		31 Mar. '44	
	Quan.	2,236	127	19,121	20,021	
Koppers	Date	30 Oct. '41	Oct. '42			Feb. '44
	Quan.	750	35	1,970		2,270
Case	Date	28 Mar. '42	Oct. '42			Dec. '43
	Quan.	2,000	?	1,414		1,414

PRODUCTION BY MODELS

	To 31 Dec. 1943
Carriage, Gun, 40mm, M1: These were built as close as possible to the British model, with equipment suitable for British use	1,392
20mm Carriage, M4, (Adapters for two 20mm guns were installed on 40mm M1 Carriage)	103
Proof facilities and development, M1	5
Carriage, Gun, 40mm, M2 Modified to improve strength, brakes, etc. and with equipment suitable for U.S. use	21,005
Total production to 31 December 1943	22,505

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PRODUCTION OF TUBE ASSEMBLIES, 40mm A.A. Gun, M1*

Facility		First Order	First Delivery	Prod. to 31 Dec. 1943	Total Prod.	Schedule Completed
Chrysler	Date	8 Sept. 1941	June 1942			March 1944
	Quan.	4,000	2,013	48,146		51,684
Pontiac	Date	21 Jan. 1942	Nov. 1942			March 1944
	Quan.	3,000	425	16,682		17,892
Otis Fensom	Date	4 June 1941	Sept. 1941		31 Mar.'44	
	Quan.	3,000	101	14,858	16,258	
War Supplies	Date	1 Dec. 1941	Sept. 1942			Oct. 1942
	Quan.	40	20	40		40

*Table shows many more tubes than either gun mechanisms or carriages. Because tubes are replaceable, two for each materiel unit were considered a minimum by the Army. However, at first, 3½ barrels were manufactured to each gun mechanism. The Navy took only two barrels to each twin mechanism. The Army took two to each single gun mechanism; later cut this to 1 3/4 barrels to each mechanism; then cut to 1½; and finally, in 1944, the ratio dropped to 1 to 1. Changing conditions of warfare made possible the changed ratio, and official opinion (May 1944) is to the effect that surplus barrels will all soon be in use as carriage manufacture is catching up with gun mechanisms.

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DECREASE IN PURCHASE PRICE OF COMPONENTS* OF
40mm AA Gun, M1
(Middle period: increasing-peak-declining)

COMPONENT	April 1942	March 1944
Gun (mechanism)	$ 4,082	$ 2,756
Tube Forging	200	115
Carriage	5,808	4,537
Oil Gears	1,325	1,574**
Remote Control System M5***	596	417
Synchronous Unit VII	54	40
Synchronous Unit XII	55	30
Synchronous Unit XXI	41	37

* Except certain off-carriage fire control equipment.

** Improved oil gears raised this price. Two months previously the price had been $884.00.

*** This and the succeeding three items are British.