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ARMY AIR FORCES HISTORICAL STUDIES: No. 60

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IN AIRCRAFT ARMAMENT
BY THE AAF
1939–1945

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The original of this monograph and the documents from which it was written are in the USAF Historical Division, Archives Branch, Bldg. 914, Maxwell Air Force Base, Alabama.

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FOREWORD

This monograph is one of a series written on the training aspects of the air program. An earlier study, AAF historical Study No. 8, Bombsight Maintenance Training, analyzes more in detail one of the subjects dealt with here but does not carry the history to the close of the war. Here we find the trends in aircraft armament training since World War I described, with special emphasis on power-operated gun turret and remote-control turret courses, together with the instructional and administrative problems encountered.

Additional information and criticism will be welcomed by the Air Historical Office.

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C O N T E N T S

Individual Training in Aircraft Armament by the AAF, 1939-1945

INTRODUCTION

The modern warplane is virtually a flying ordnance shop. It bristles with machine guns and cannon to attack or defend itself against enemy aircraft; some types are loaded with tons of bombs to be dropped with such accuracy that the war fabric of the enemy will be seriously broken. For the sake of convenience, the machine guns, cannon, and bombs carried on a plane, and the elaborate equipment necessary to operate them--power operated and remotely controlled gun turrets, bombsights, automatic pilots, and the like--are known as aircraft armament. Closely allied to aircraft armament are the spray tanks and other chemical containers with which planes may be equipped for lethal or camouflage purposes.

In the Army Air Forces, responsibility for the routine maintenance of armament and chemical warfare equipment in first-class fighting condition is placed on a commissioned ground duty officer known as the armament and chemical warfare officer; he supervises the work performed on the flying line by a crew of enlisted aircraft armorers, bombsight mechanics, power operated turret mechanics, and remote control turret mechanics. Repair work and maintenance of other than a routine nature, known as "third and fourth echelon maintenance" or "depot overhaul," is performed usually at depots and subdepots of the Air Materiel Command by enlisted men and

civilian employees. In the case of some of the heavy and very heavy bombers, enlisted aircrew members have been given training in armament as well as flexible gunnery so that they could not only operate but if necessary maintain the armament equipment.

Chapter I

EARLY ARMAMENT TRAINING

Training for Enlisted Men

The exact date when the technical schools of the Air Service began teaching aircraft armament to enlisted personnel is not known. The records of the "Air Service Mechanics Schools" at Kelly Field, Texas, and at St. Paul, Minnesota, which gave technical training during World War I, list 16 trades; but armament was not among them.[1] When the school at Kelly Field was reorganized in October 1919, under the direction of Maj. George E. Stratemeyer, armament was one of the 21 courses offered.[2] In April 1921 the school was moved from Kelly Field to Chanute Field, Ill., and armament training was given as one of the courses in the Department of Mechanics there. Chanute remained the home of aircraft armorer training for the next 17 years.[3]

Between 1919 and 1930 armament training was treated more or less as a stepchild of the Department of Mechanics. Students taking the course were mediocre at best—in many cases they were men with as many as 16 years of previous Army service spent as cooks or mess sergeants who felt that they could "handle" the course. This situation stemmed from the fact that at most airfields armament was considered an unimportant activity, and comparatively few graduates of the technical school course were ever actually assigned to armament work.[4] From the fragmentary records which survive from this period, it appears

that normally five classes were enrolled each year, with eight or less students in each class. The usual length of the course was five and a half months, although occasionally it lasted a month longer. There was considerable variation in the topics presented from class to class; but the following curriculum, given to a class graduating on 25 May 1928, is probably as representative as any:[5]

Subject	Hours
Mathematics and Principles of Shop Work	147
Machine Guns	153
Small Arms	48
Bombs and Pyrotechnics	45
Ammunition and Explosives	15
Bomb Releases and Sights	117
Advanced Field and Shop Work	129

During the first half of the 1930's two events occurred which did a good deal to improve the caliber of armament training. In 1930 the armament course was withdrawn from the Department of Mechanics, and assigned to a new Department of Armament. The step served to impress upon men in the Air Corps the importance with which armament work was coming to be regarded. Gradually better men were sent to Chanute to take the course and were later assigned to armament work in operational units.[6]

The second development followed the appointment of Capt. Herbert A. Anderson as director of the Department of Armament in July 1935. Captain Anderson undertook a thorough reorganization that included renovation of the department's classrooms, replacement of its antiquated teaching equipment, and a revision of its curriculum.

Starting with the school year 1935-36, the course of instruction was divided between four principal divisions: (1) Elementary and Specialized Division; (2) Machine Gun Division; (3) Bomb Division; and (4) Chemical Warfare Division. Each of these divisions was supervised by a commissioned officer charged with the responsibility of revising the subject matter of the course as well as the texts and teaching methods through which it was presented. The instructor ranks were combed thoroughly, and only men of unusual ability were retained. Instructors were told that they must master all phases of the course so that they could teach any part of it and thus fill any vacancy that might occur.[7] The course called for 582 instructional hours over a 24-week period; 5 weeks were devoted to basic mechanic subjects, the remaining 19 to practical armament instruction. The subjects taught and the time devoted to each were as follows:

Subject	Hours
Mathematics	45
Mechanical Drawing	39
Elements of Metal Work	57
Electrical Controls	30
Small Arms	48
Gun Cameras	30
Aircraft Machine Gun Sights	27
Heat Treating	15
Aircraft Machine Guns	108
Chemical Warfare Materials	30
Bombsights and Camera Obscura	48
Bomb Racks	60
Explosives and Ammunition	30
Tow Targets	15

In the opinion of Captain Anderson, the men graduated during that year were the first armorers truly qualified to work on modern air-

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planes.

The following year, 1936-37, the course was extended to 32 weeks. The additional eight weeks enabled the school to give three more weeks to basic mechanic subjects and five additional weeks to more thorough training in electrical controls, the recognition and correction of malfunctions, and increased experience in handling live ammunition and high explosives. The last type of training was needed, it was felt, to overcome the students' native fear of explosives.

Even these modifications did not fully answer the need for "practical" instruction, school officials felt. One of the chief factors behind the move of the Department of Armament from Chanute to newly established Lowry Field, Colo., in February 1938 was the fact that close to Lowry were 64,000 unpopulated acres. Here students could learn to handle live bombs and high explosives and acquire some familiarity with gunnery and bombing practices, without endangering the lives of civilians—features not available at Chanute.

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Within a few months of the move to Lowry, the armament course was again drastically reorganized. With the hope of shortening the course, greatly increasing the number of graduates, and stepping up the efficiency of the individual students, six highly specialized courses, each 24 weeks in length, were set up. Four were intended for inexperienced enlisted men: (1) primary attack aircraft armament; (2) primary pursuit aircraft armament; (3) primary bombardment aircraft armament; and (4) observation aircraft armament. A fifth course, the so-called Advanced Armorer's Course, was designed for men who had had at least a year and a half of experience in aircraft armament work,

preferably had graduated from one of the primary armament courses, but in any event had completed the basic mechanic phase in a technical school course. A sixth course, a Master Armorer's Course, was initiated for men who, among other qualifications, had at least five years of experience in the Air Corps, held a rank of sergeant or higher, had previously graduated from the Chanute armament course, possessed "outstanding interest in the subject of armament and exceptional mechanical ability," and were "considered reliable in every respect." It was expected, when this plan went into effect, that 255 men would be trained in the course of the year—an increase of more than tenfold. Approximately two-thirds of the students were to be in the four primary courses.

As might have been expected, the plan was so complicated that it proved unworkable and was dropped before the end of the school year. Another factor which hastened its abandonment was the inauguration of a vast Air Corps expansion program at the beginning of the school year 1939-40.[10] In each of the two years the six-course plan was in effect 14 separate classes were matriculated, but the annual attendance never was higher than 196.

Training for Officers

An Air Corps Engineering and Supply Conference held during 1927 at the Air Corps Materiel Division, Wright Field, reached the conclusion that there was great need for the training of officers whose duty it was to supervise armament work. Accordingly, during the school year 1927-28, a course for Regular Army officers was established in the

Department of Mechanics at Chanute Field. It became the practice to give armament training to one class of officers each year, adhering rather closely to the curriculum of the enlisted men's course. When the separate Department of Armament was organized at Chanute in 1930, both officers' and enlisted men's courses were transferred to that department.[11]

In 1934 the notion that officers ought to be equally familiar with aircraft maintenance and aircraft armament led the Chanute authorities to undertake an unhappy experiment. The two subjects were combined into one 10-month course, seven months being devoted to aircraft maintenance subjects and three months to armament topics. Two years of trial convinced the authorities that three months was far too short a period to cover armament--at least in peace time. At the start of the school year 1936-37 the armament course again became a separate entity, now seven months in length.[12]

From the fragmentary records surviving from this period, it appears that in the 12 years between early 1928 and mid-1939, 15 classes with a total of 153 officers were graduated. Only in 1933, 1934, and 1936 was more than a single class graduated. The class records reveal that the topics presented varied greatly from year to year.[13]

A notable experiment was conducted in connection with the classes graduated in 1935 and 1936. The officers taking the course at Chanute in these years were taken to Fort Knox, Ky., Fort Bragg, N. C., and an Air Corps tactical center near Valparaiso, Fla., for short periods

of practice gunnery and bombing missions. These field trips not only provided the students with valuable experience, but furnished the Air Corps with evidence of the desirability of bombing and gunnery practice in connection with armament training.[14]

In February 1939, Maj. Gen. Henry H. Arnold, Chief of the Air Corps, ordered all armament training of Regular Army officers discontinued so that the facilities and personnel of the Air Corps technical schools might be entirely devoted to the training of enlisted technicians to meet the demands of the Air Corps expansion program. Accordingly, the eight Regular Army officers who graduated 30 June 1939 were the last to receive armament training for some years.[15]

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Chapter II

TRENDS IN ARMAMENT TRAINING, 1939-1945

By early 1939 the designs of the Facist powers had become so evident that Air Corps officials began to assess their resources to learn how they might meet any eventuality. Out of this stock-taking was developed a program designed to add 25,000 more enlisted men to the Air Corps by 30 June 1940. Of these, 1,584 were to be trained as aircraft armorers and 288 as bombsight mechanics between 7 August 1939 and 7 July 1941.[1]

Once the program got under way, the practice was to send all Air Corps recruits to one of six fields possessing a basic training center. During their first month the men were given basic military training, innoculations, and tests to determine their capacity for technical training. Those found qualified for training as armorers were sent to Scott Field, Ill., for a one-month course in basic technical training--the instruction in shop mathematics, drafting, blueprint reading, elementary metalwork, and electricity--which had previously been given during the first weeks of the course at Lowry. Upon completion of this, the recruits were sent to Lowry to take the regular armament course.[2]

The procedure followed in billing the quotas for bombsight maintenance students, however, remained substantially unchanged from what it was before the expansion period. No recruits were admitted to the course; only men with three years' Army experience, a rating of qualified

aircraft armorer, and the specific recommendation of their commanding officer were admitted. Bombsight students came on quotas from airfields and depots, and normally returned to them upon completion of the course.[3]

To make room for the additional numbers of students in both courses, school buildings and barracks of the temporary type were constructed as rapidly as possible. To obtain the necessary new complements of instructors, students graduating from the course were impressed into teaching service.[4] Lowry had little difficulty in meeting the goal set up for it; by the end of 1939 the school was regularly entering students at close to the desired rate--66 armorers and 12 bombsight mechanics a month.[5]

The alarming successes of the German Army in overrunning Western Europe and the threatened German invasion of Great Britain during the spring and summer of 1940 caused the Air Corps to supplant the first expansion program long before training under it had been completed. This second program, the so-called 136,000-man program, went into effect late in September 1940, and called for the training of 5,775 armorers and 602 bombsight mechanics by 1 April 1942.[6]

The Lowry officials encountered considerable difficulty in achieving the pace that was now set for them. The housing, messing, and classroom facilities could accommodate only 264 students at one time.[7] For a little more than a month, from late September until the middle of November 1940, the school operated on a two-shift basis,

which relieved the strain on the available classroom--if not mess and barracks--facilities.[8]

Not until the end of January 1941 did the War Department grant the funds necessary to construct eight temporary school buildings.[9] As a result, it was not until the middle of 1941 that students were entering Lowry at a rate great enough to achieve the goal.[10]

As soon as the 136,000-man program was put into effect, the basic mechanic course given at Scott was discontinued and the subject matter previously included in it added to the armament course at Lowry without, however, any increase in the over-all length of the course. Although great numbers of men became available to the Air Corps through the operation of Selective Service about this time, none of the men so inducted were assigned to armament training. It was the view of the Air Corps that as Selective Service inductees would remain in the Army only a year, it was not worth while giving these men an extended period of technical training only to have them return to civilian life soon afterward.[11]

Owing to rapid and prodigious growth of the Air Corps, a need for additional officers to supervise the work of enlisted aircraft armorers and bombsight mechanics began to be felt during this period. Late in 1940 it was decided that a course of training for aviation cadets should be established. Upon graduation these men were to be commissioned second lieutenants and assigned to ground duty as armament and bombsight officers. At first it was expected that this course would be filled with eliminees from the flying cadet course;

but when this source rapidly became depleted, quotas were filled with promising enlisted men and men from civilian life with some technical training and experience. After debate as to whether all the cadets should be given training in bombsight maintenance as well as armament, it was determined that approximately 25 per cent of them should be given a cadet bombsight course after completing a cadet armament course. This quota was based on the number of officers needed at that time for bombardment squadrons. The first class of 32 armament cadets entered Lowry on 3 March 1941; additional classes of the same size entered every four weeks thereafter.[12]

The remarkable demonstration in Europe of the effect of air power during 1940-41 convinced the Air Corps that it must again raise its goals for the production of planes, aircrews, and ground crews. On 19 August 1941 it put into effect a program designed to produce 100,000 technicians a year--or twice as many as were then being graduated. Inasmuch as at the time the plans for the program were being drawn up, armorers were being trained at the rate of 5,005 a year and bombsight mechanics at approximately 500 a year, new goals were set at 10,000 and 1,000, respectively. These were to be accomplished through the use of two shifts--an "A" shift which attended classes from 0400 to 1245, and a "B" shift in session from 1300 to 2200 daily except Saturday and Sunday. No increase in classroom and teaching equipment was necessary, although additional instructor personnel had to be chosen and trained and more economical use made of housing facilities.[13]

The work of the Lowry Armament Department in meeting the demands of the 100,000-technician program, however, was made more difficult by the inauguration on 15 September 1941 of a new course in power operated turrets. Phases for such a course had been under discussion for a whole year, but it was not until actual installation of four types of power operated turrets in Air Corps bombers began to take place in the late summer of 1941 that the school officials were given word to go ahead. The policy was to take the most outstanding 10 per cent of each armament class and give these men 12 weeks of training in turret maintenance. Actually, the shortage of qualified instructors, the complete lack of teaching equipment, and indecision as to which types of turrets were actually going to be used in combat caused the turret department to follow a somewhat spasmodic course during its first months.[14]

The Japanese attack on Pearl Harbor on 7 December 1941 and the resulting declaration of war against the Facist powers led to an immediate scrapping of the 100,000-man program and the replacement of it by a far more ambitious program. The so-called Victory Program, which was put into effect during the following month, called for the training at the rate of 36,090 aircraft armorers, 3,000 power operated turret mechanics, 3,480 bombsight mechanics, and 875 armament officers a month by 31 December 1942.[15]

These goals had all been met by the end of 1942. In accomplishing them, some drastic wartime measures were resorted to. Immediately after

Pearl Harbor the length of the courses was reduced by approximately one-fifth, through the introduction of a six-school-day week in all courses and three shifts in all courses except the cadet course; and through the elimination or shortening of phases not considered absolutely essential in the case of the enlisted armorer course. The size of the classes, which were now begun at more frequent intervals, was increased.[16] Beginning in October 1942 all courses except the cadet courses were given on a seven-day week schedule, with one-seventh of the students and instructors off each day of the week.[17]

As soon as the nation entered the war, Lowry abandoned its policy of refusing to give technical training to Selective Service inductees.[18] Even in the case of the bombsight mechanic course, where previous Army experience had been considered indispensable, the shortage of old-time enlisted men made the school willing to accept even relatively recent recruits as long as they had graduated from the enlisted armorer course and met other physical, educational, and security prerequisites.[19] For the cadet armament course, the AGCT (Army General Classification Test) score of 110 demanded of all officers was another requirement. In general, any men eligible for Army service was considered physically qualified for training in armament subjects, although from time to time limits were placed on the number of "limited service" men acceptable. An AGCT score of 100 and a mechanical aptitude score of 100-approximate average--were set as the minimum for training in the enlisted courses.[20]

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But the large quotas of the Victory Program could not have been met if the housing and classroom facilities available for armament training had not been considerably expanded. During July 1942 the enlisted armament course at Lowry was moved to a newly constructed school area known as Lowry Field No. 2.[21]

A few days later a large new school, devoted exclusively to armament training, was opened at Buckley Field, a few miles east of Lowry Field in Colorado.[22] Additional facilities were made available for armament training in January 1943 when the cadet armament course was moved to an AAF technical school at Yale University, where all ground duty cadet training was being centered.[23]

Within two and a half months after the move of the enlisted armament course to Lowry No. 2 and Buckley, a policy of specialization in training was introduced which made it possible further to reduce the length of the course by one-quarter. Starting late in September 1942 the course curriculum at Buckley was revised to train armorers for service in pursuit squadrons, that at Lowry to train armorers for service in bombardment squadrons.[24]

The entry of the United States into the war produced an immediate need for numbers of enlisted men capable of performing third and fourth echelon maintenance of armament equipment in the depots and subdepots of the Air Service Command. To meet this need the ASC in June 1942 set up the Armament Training School at the Indiana State Fairgrounds, Indianapolis, Indiana. Courses in bombsight repair and power operated gun turret repair on the depot overhaul level were started shortly

thereafter. Recognition that the newest types of planes were to employ a complicated system of remotely controlled guns led to the establishment of a Central Fire Control Equipment Course at Indianapolis the following November. The enlisted students for the bombsight and power operated gun turret (POGT) courses came from the graduating classes of Lowry's first and second echelon courses; those for the CFCE course from Indianapolis POGT course. In February 1943 administrative responsibility for the Armament Training School was assumed by the Technical Training Command, which thus was enabled to coordinate its work more closely with that done at Lowry.[25]

In January 1943 an important new course on the first and second echelon level was established at Lowry. At first called the Central Fire Control Equipment Course, later the Remote Control Turret Mechanic Course, this was designed to teach the maintenance of the new fire-control systems being installed in B-29 and B-32 aircraft. As the course included some very difficult subject matter, only men with unusual backgrounds--an AGCT score of 120 or over and experience in radio and electronics--were admitted.[26]

During the first half of 1943 the AAF approached the 2,500,000-man strength which had been calculated as necessary to win the war in the air. The number of recruits made available to the AAF by Selective Service each month was sharply reduced. Losses of ground-crew men, including armorers, were light, and resulted in moderate demands for replacements. In the two-year period between the middle of 1943 and V-J

Day in September 1945, armament training was characterized by three factors: a sharp diminishment in the number of men under training; a reduction in the number of schools offering armament training until finally Lowry was again the only armament school; and the lengthening of the curricula of courses to permit more comprehensive and thorough instruction and the addition of newly adopted types of equipment. There is no reason to believe, however, that AAF training officials fully recognized that these factors were at work, at least not until late in 1944; up to that time the student flow, course length and content, and choice of schools followed a chaotic path for every one of the courses, indicating that improvisation was the rule at the higher headquarters.

The reduction in the number of students was most precipitous in the case of the basic armament and power operated turret courses. The enrollment of the armament course dropped from 12,547 in April 1943 to 2,292 in December 1944 to 14 on V-J Day. In the case of power operated turrets, the decline was from 248 in April 1943 to 120 in December 1944 to 2 on V-J Day.[27] The drop would have set in earlier and would have been even sharper if it had not happened that in the last days of 1942 the Directorate of Individual Training issued a directive that henceforth all flexible gunners must be trained in some technical specialty either before or immediately after attending gunnery school. This meant that beginning in early 1943 large numbers of flexible gunnery graduates or men earmarked for service as gunners were assigned to the basic armament course, the power operated gun turret.

course, and the remote control turret mechanic course. After this trend reached full force, approximately three-quarters of the basic armament students were gunners. But by early 1945 Headquarters, AAF concluded that to conserve equipment and personnel no additional armorer-gunners ought to be trained. There now appeared to be a surplus of this type, at any rate.[28] Precipitous, although not to the same degree, was the decline in enrollment in the bombsight course. In April 1943, 1,255 bombsight mechanics were in training at Lowry, while in December 1944 there were only 186. But by V-J Day there was actually a slight increase, to 198. This was the result of the AAF policy, inaugurated during the interval, of releasing enlisted men according to a point system in which length of service was an important factor. Inasmuch as most bombsight mechanics then in the AAF had long records of service, and as the AAF expected to need the services of this type of technician indefinitely, it was planned to continue such training steadily on this modest level.[29]

Still another factor served to slow down the volume of officer training in armament. By the spring of 1944 it became apparent that the AAF had commissioned more ground duty armament officers than it could possibly use. But it did not seem advisable to curtail armament training on the officer level entirely: armament officers would be needed in the postwar AAF. So the nature of the course was changed drastically; rated officers who planned to make a career of the AAF were to be given the training.[30] Thus the drop in the enrollment of

the officer course was relatively slow: from 305 in April 1943 to 215 in December 1944 to 64 on V-J Day.[31]

In the case of one armament course—that in remote control turrets—the enrollment actually increased from three students in June 1943 to 1,226 in December 1944 to 2,872 on V-J Day. The reason for this gain was, of course, that remote control turrets were a type of equipment found only in the new very heavy bombers which the AAF was putting into operation in the war against Japan.[32]

While the volume of armament training was declining in general, the AAF made a comparable reduction and concentration of training facilities. The Armament Training School at Indianapolis was closed in January 1944; and the three-depot overhaul courses—bombsight, power operated turrets, and remote-control turrets—were resumed at Lowry during the following spring. The fulfillment of training requirements for armorers for pursuit squadrons and the diminution of needs for bombardment squadrons left the AAF with a surplus of facilities for the basic armament course. In the spring of 1944 the armament school at Buckley was closed, and Lowry No. 2 once again became the only school giving this course. During the summer of 1944 the AAF abandoned the facilities it had leased at Yale University, at the same time discontinuing the cadet armament course. The successor course, an Armament and Chemical Warfare Officers Course for rated personnel, was opened at Buckley in July, only to be moved to Lowry in January 1945. Thus the end of the war found the AAF giving all of its aircraft armament training at the same single station it had used at the start

of the expansion period, Lowry Field.

With the demand for mere numbers satisfied, after the spring of 1943 AAF officials could give more attention to the quality of the training. One of the first steps taken was to drop the third, or night, shift, which was generally conceded to present barriers to good teaching which were difficult to surmount. During 1945, as most of the courses shifted to a "token" basis, a single shift became sufficient.

The school authorities undertook to extend the length of all the courses so as to make instruction more thorough and to permit proper presentation of new equipment which the AAF was adopting as it waged the war in the air. These requests were resisted for a time by Headquarters, AAF, which held that the necessity for economizing personnel and equipment, as well as "the present policy of this Headquarters" made it impossible to grant them. During the latter half of 1944 and in 1945, however, requests to extend the courses from one to three weeks were granted in most instances.

In the case of the basic armament course, where perhaps the sacrifices of quantity to quality had been greatest, the shift back to peacetime training standards was slower in coming than the school authorities would have liked. At the time of the discontinuance of the pursuit armament course in the spring of 1943, they proposed that hereafter basic armament training cover comprehensively and thoroughly all phases of armament work—even if that should require a doubling of the length of the course. The need for armament training for flexible

gunners provided Headquarters, AAF with an excuse to postpone the granting of this request. Thus it was not until the summer of 1945, when the AAF had a surplus of both gunners and ground duty armorers, that the course was reestablished on a standard compatible with that prevailing before the expansion period, but incorporating all the technical and pedagogical lessons learned during three and three-quarters years of war.

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Chapter III

ARMAMENT COURSES FOR ENLISTED MEN

As soon as Air Corps officials realized that under the so-called Augmentation Program they would have to increase their training rate more than 300%, they decided to scrap the complicated three-level armament training they had been giving at Lowry Field and concentrate on a single three-month basic armament course. This new course started with a four-week phase called Basic Mechanics, given to all Air Corps recruits selected for technical training. The principal features of this phase, conducted at Scott Field, Illinois,[1] were as follows:

	Subject	Hours
I.	Shop Mathematics	27
II.	Mechanical Drafting and Blueprint Reading	26
III.	Air Corps Fundamentals	27
IV.	Elements of Metalwork	40
V.	Elements of Electricity	40
	TOTAL	160

Upon completing this phase, armament students were transferred to Lowry Field, Colorado, where they started on the following 12-week course of study:

	Subject	Hours
I.	Chemical Warfare Materials Agents; weapons; supply; technique and meteorological factors affecting their use; chemical tanks; operation loading; safety precautions.	24

	Subject	Hours
II.	Explosives and Ammunition Military explosives, pyrotechnics, and ammunition use in the Air Corps; their composition, uses, properties, handling storage, safety precautions, inspection, and packing.	32
III.	Small Arms and Gun Cameras Description, nomenclature, operation, care, and maintenance of service-type shotguns, pistols, rifles, and gun cameras; film interpretation; details of range procedure and principles involved in the firing of a pistol and a shotgun.	32
IV.	Electrical Armament Controls Operation, maintenance, and inspection of all electrical armament controls.	32
V.	Aircraft Machine Guns Description, nomenclature, theory of operation, adjustment, maintenance, inspection, handling during operation and correction of malfunctions during firing of caliber-.30 and caliber-.50 machine guns.	120
VI.	Synchronizers and Gun Installations Description, nomenclature, operation, installation, maintenance, and inspection of standard aircraft machine gun synchronizers, controls, and mounts.	80
VII.	Bomb Racks and Tow Target Equipment Description, nomenclature, operation, installation, and maintenance of service type internal and external bomb and flare racks, shackles, and tow target reels; chemical carrying and release mechanisms, their operation, installation, and maintenance.	80
VIII.	Aircraft Machine Gun Sights Description, theory, installation, harmonization, maintenance, and inspection of service-type aircraft machine gun sights.	40
IX.	Field Exercises Practical work in inspection, installation, and maintenance of machine gun synchronizers; installation and harmonization of machine gun sights.	40
	TOTAL	480

When the 136,000-man program, put into effect in September 1940, increased training goals of basic armorers 400%, the Air Corps discontinued the basic mechanic phase at Scott Field. Thereafter armament students reported directly to Lowry for both the basic mechanic and armament phases.[2] The material in the former phase was compressed into two weeks so that the entire course could be given in 14 weeks:[3]

	Subject	Hours
I.	Shop Mathematics	16
II.	Metal Work	40
III.	Soldering	8
IV.	Electrical Armament Controls	40
V.	Explosives and Ammunition	32
VI.	Chemical Warfare Materials	24
VII.	Small Arms and Gun Cameras	40
VIII.	Aircraft Machine Guns	120
IX.	Aircraft Machine Gun Sights	40
X.	Synchronizers and Installations	80
XI.	Bomb Racks, Flare Racks, and Tow Targets	80
XII.	Field Exercises	40
	TOTAL	560

A year later the course was lengthened to 15 weeks to permit the addition of a second week of field exercises.[4]

The demand for armorers rocketed when the United States entered World War II late in 1941: between that time and March 1943, when the peak was reached, the training rate had increased about 900%. To meet these prodigious increments the course was progressively shortened; and the content of the instruction was made ever narrower—or more "specialized," as the term was. The day after the attack on Pearl

Harbor, the length of the course was ordered slashed from 15 weeks to 12. This was accomplished by making Saturday a regular eight-hour school day, and by eliminating certain "not absolutely essential" parts of the electrical armament controls, explosives and ammunition, metal work, chemical warfare, machine gun, and small arms phases.[5]

The course length was again reduced in September 1942, in compliance with a directive of the Technical Training Command (TTC) that as far as possible all technical courses were to be specialized. Two types of armament were to be taught--pursuit armament at recently opened Buckley Field, and bombardment armament at the new Lowry Field No. 2. Both courses were to be nine weeks in length.[6] The phases and distribution of time of the two courses were as follows:[7]

Bombardment Armament		Pursuit Armament	
Phase	Hours	Phase	Hours
Aircraft Machine Guns .30-and .50-cal. machine guns, fixed and flexible; 20-and 37-mm. aircraft cannon.	126	Aircraft Machine Guns .30-and .50-cal. machine guns, fixed; 20-and 37-mm. aircraft cannon.	126
Electrical Armament Controls	31½	Electrical Armament Controls	21
Explosives and Ammunition	10½	Explosives and Ammunition	21
Bomb Racks	42	Synchronizing	84
Field Exercises	42	Aircraft Gun Sights	42
Power Turrets	126	Field Exercises	84
TOTAL	378	TOTAL	378

The principal differences between the two courses lay in the bomb rack and power turret phases, which treated equipment found only in

bombardment squadrons; and the synchronizing and aircraft gunsight phases, which covered material which would be of particular value to men who would be assigned to pursuit squadrons. During the field exercise phases, conducted in hangars, embryonic bombardment armorers were assigned work on bombers and bomber equipment, while prospective pursuit armorers practiced on fighter aircraft and equipment. Specialization was not carried to such a degree that no information on bombardment armament was given to pursuit armorers, or vice versa. During the 21 hours of instruction on explosives and ammunition given to pursuit armorers, there was some familiarization instruction on bombs and bomb shackles.

When the AAF reached the limits of its expansion program in the spring of 1943, certain new factors appeared which considerably affected the curricula of the basic armament course. A few armorers were needed as replacements in pursuit and bombardment squadrons. Now, however, most of the students would be men earmarked for training as flexible gunners; they would need bombardment armament training. The Technical Training Command directed that beginning early in May almost three times as many men would enter the bombardment course as would enter the pursuit course (717 bombardment armorers per week as compared with 265 pursuit armorers)[8]. Inasmuch as the facilities at Lowry No. 2 and at Buckley had been set up on the assumption that the number of bombardment armorers and pursuit armorers to be trained would be approximately equal, considerable readjustment was necessary to meet the new conditions. All equipment and

personnel on the aircraft machine gun phase was concentrated at Buckley, beginning in May. Thus all basic armament students now began their training at Buckley; upon completion of the machine gun phase, 73 per cent went to nearby Lowry for the later phases designed for bombardment armorers, while the remaining 27 per cent remained at Buckley to take pursuit armament.

The Technical Training Command officials recognized that this arrangement was at best a makeshift. They invited the authorities at the two schools to propose plans for the improvement of the course.[9] Two plans were forthcoming, both based on the assumption that inasmuch as the demand for large numbers of armorers had now ceased, the course ought to be more comprehensive, more thorough, and considerably less hurried.

The first plan called for a 16-week course--eight weeks to be spent at Buckley studying machine guns, cannon, explosives and ammunition, electrical armament controls, and such specialized pursuit-armament subjects as synchronizing and machine-gun sights; and a second eight-week period to be spent at Lowry covering bomb racks and power-operated turrets. The phase on turrets would be so comprehensive that it would obviate the need for the eight-week advanced course on power turrets then being offered at Lowry. It was suggested that a more thoroughly trained, all-around armorer would result from this course.[10]

The second proposal contemplated a course on the same general

principles, but the pace was to be even less hurried--22 weeks in length. The first 10 weeks, devoted to general and pursuit armament phases, were to be given at Buckley. Of the 12 weeks to follow at Lowry, nine were to be devoted to bomb racks and thorough training in power operated gun turrets, and three weeks to exercises in maintenance of bombardment and pursuit aircraft.[11]

No action was taken on either of these proposals for more than two months. Finally, on 17 July 1943, the Assistant Chief of Air Staff (AC/AS), Training of Headquarters, AAF gave orders that the pursuit and bombardment courses were immediately to be combined into a single 12-week course. The switch in curriculum was to be conducted in such a way, the directive specified, that there would be no interruption in the regular flow of armorer graduates to the flexible gunnery schools.[12]

When this directive reached Lowry Field, where it was generally supposed the combined course would be located, the school authorities protested vigorously that 12 weeks was not long enough a period to train an armorer comprehensively. In August they submitted as an alternative a 16-week curriculum that was in its essentials similar to the one they had proposed three months earlier.[13]

The suggestion was rejected by the Training Command (the command which was created by the merging in July 1943 of the AAF Technical Training and the AAF Flying Training Commands), which now adopted the stand taken by Headquarters, AAF that a 12-week period was long enough.

The 16-week curriculum, Headquarters, AAF told the Lowry officials, contemplated too thorough a presentation of turret maintenance. Familiarization instruction on this equipment would be adequate.[14] None too enthusiastically, the Lowry and Buckley officials complied with the directive. By 13 October 1943 they had shifted around enough personnel and equipment to put the following 12-week curriculum into effect:[15]

	Subject	Hours
I.	Explosives and Ammunition	18
II.	Chemical Warfare	18
III.	Electrical Armament Controls	36
IV.	Bomb Racks	36
V.	Cal. .50 Aircraft Machine Guns	36
VI.	Cal. .30 Aircraft Machine Guns	12
VII.	20-mm. Aircraft Cannon	24
VIII.	37-mm. Aircraft Cannon	24
IX.	75-mm. Aircraft Cannon	12
X.	Synchronizing	36
XI.	Aircraft Machine Gun Sights	24
XII.	Gunsight Aiming Point Camera	12
XIII.	Power Operated Gun Turrets & Tow Targets Martin upper turret; Consolidated tail turret; Emerson nose turret; Sperry upper locally controlled turret; Sperry lower ball turret; Bell M-6 and M-7 twin gun mount; Bendix upper gun turret; Bendix lower gun turret; Bendix chin turret type A-16; tow targets, windlasses, and related equipment.	108
XIV.	Field Exercises Pursuit and bombardment armament.	36
	TOTAL	432

This curriculum is interesting because it was a reversion to almost the same order of presentation of subject matter which had been used before the course had been made "specialized." Such

[redacted]

subjects as explosives and ammunition, chemical warfare, electrical armament controls, etc., were relatively easier than machine guns and cannon for a beginning student to grasp, the school authorities felt, so it was better to present them at the start of the course.[16] The phase on chemical warfare was restored in response to a protest from the Air Chemical Officer that such training ought to be given armorers because "virtually all tactical aircraft was a potential carrier of spray tanks."[17]

The new curriculum was noteworthy for another reason--it included subject matter which the school authorities had long believed ought to be included in the basic armament course, but for which they had never been able to secure approval from higher headquarters. In this category was instruction on the new 75-mm. cannon, used on B-25 airplanes,[18] the Emerson nose turret, and the Bendix upper, lower, and chin A-16 turrets, which were being widely installed on heavy bombers. The 42 hours specified in the new 12-week basic armament curriculum permitted familiarization training for all armorers.[19]

Lowry and Buckley had barely begun using the 12-week curriculum when their equanimity was upset by the receipt of AAF Training Standard No. 80-51, for aircraft armorers, dated 2 October 1943. At this time Headquarters, AAF, in an effort to standardize AAF training, was preparing a series of directives listing, in some detail, proficiencies which individuals must attain to be considered adequately trained in technical specialties. The Lowry and Buckley officials had understood

that the preliminary draft of the training standard for aircraft armorers would be drawn up in Headquarters, Western Technical Training Command (WTTC), inasmuch as the greater part of armament training was conducted under the supervision of that command.[20]

The Lowry officials in particular had several objections to AAF Training Standard No. 80-51. The wording of a statement of the general objectives of armament training and of another dealing with equipment maintenance seemed to them inaccurate in details and open to misinterpretation. They suggested substitute statements to avoid these objections.[21]

More serious so far as the school was concerned were certain specifications. Paragraph 2a, for example, provided that an armorer be able to demonstrate his proficiency in the "blindfold disassembly and assembly of the caliber .50 and caliber .30 machine gun . . . ." As they then were giving the course, the school authorities had time for a blindfold test only on the caliber-.50 machine gun. They did not consider it advisable to readjust the training schedule, "since the caliber .30 gun has a very limited use." Nor was the Lowry school meeting four other specifications:[22]

2c. Care, adjustment, and operation of all small arms and weapons used by the Army Air Force units.

i. Adjustment and use of shut traps.

l. Safety regulations, range rules, and procedure.

m. The use and purpose of all supply, maintenance and other forms, plus replenishment of supplies and survey procedure.

The Lowry officials and the Western Technical Training Command authorities agreed that one of three things should be done: (1) The training standard must be revised, omitting the parts in question; or (2) the length of the course must be extended to 15 weeks to allow time for the addition of necessary instruction; or (3) the familiarization training given on power turrets must be considerably reduced in scope to provide time for the addition of the required material. The Lowry officials inclined toward the second alternative.[23]

When the Training Command presented to Headquarters, AAF these suggestions, together with its own recommendation that the course be extended to 15 weeks, Headquarters, AAF replied that "in view of the existing need of armorers for new units," the request could not be granted, but that it should be resubmitted in about four months.[24]

Meanwhile, however, the Lowry authorities had attempted to improve the general standard of the course through their own efforts. With the authorization of the WTTC, in January 1944 they issued a detailed statement of proficiency standards which students were expected to attain in each phase of the basic course. Before being adopted they were reviewed by officers and enlisted men recently returned from combat duty who had had experience in the type of work included.[25]

By the start of 1944 the AAF had trained all the armorers it would need as replacements. Accordingly, on 16 February, the Training Command announced that henceforth the only men to be given basic

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armament training would be men earmarked for service as armorer flexible gunners.[26] This, so the ATTC concluded, made it possible to eliminate from the armament curriculum much of the material which was also curriculum of the flexible gunnery course. It had been impracticable to avoid the duplication of such material earlier, when embryonic armorer-gunners and ground duty armorers were taking the armament course side by side. Through the elimination of such phases as synchronization--useful only to pursuit armorers--and the introduction of a new type of specialization, it was possible to reduce the length of the armament course from 12 to seven weeks.[27] As the quotas of armorer-gunners would be small enough to be accommodated at Lowry No. 2, it was decided to discontinue giving the course at Buckley.[28]

Training under the seven-week specialized curriculum began at Lowry on 24 April 1944. The syllabus, originally drawn up by the Lowry officials,[29] was as follows:

Phase	Days
I. Basic Armament--Taken by all Students	
Technical orders and supply	1
Bombs and fuzes	2
Caliber .45 pistol	1
Caliber .50 aircraft machine gun	9
20-mm. automatic aircraft gun	5
TOTAL	18
II. Heavy Bombardment Armament--Only for B-24 Aircrews	
Electrical armament controls and bomb racks	9
Power operated gun turrets	
Gun sights and cameras	2
Martin upper turret	3
Sperry lower ball and untractable turret	3
Consolidated tail turret	3
Flexible gun	1
Field test on B-24 airplane	1
TOTAL [redacted]	22

Phase	Days
III. Heavy Bombardment Armament--Only for B-17 Aircrews	
Electrical armament controls and bomb racks	9
Power operated gun turrets	
Gun sights and cameras	2
Sperry upper turret	3
Sperry lower ball and retractable turret	3
Bendix chin turret	2
Bell gun mount (M-6, M-7)	1
Flexible guns	1
Field test on B-17 airplane	1
TOTAL	22
IV. Medium Bombardment Armament--Only for B-25 or B-26 Aircrews	
Electrical armament controls	9
Power operated gun turrets	
Gun sights and cameras	2
Harmonization	1
Martin upper turret	3
Bendix upper turret	2
Bell gun mounts	1
75-mm. aircraft gun	2
Flexible guns	1
Field test on B-25 and B-26 airplanes	1
TOTAL	22
V. Miscellaneous Armament Equipment--For all Students	
Tow targets, windlasses, Shut traps	2
TOTAL	2

Quotas for the second, third, and fourth phases were set by the flexible gunnery schools, which in turn were determined by commitments for operational training and assignment of combat groups overseas. The first classes were taught according to the following percentages:[30]

36% B-17 crew members
36% B-24 crew members
28% medium bombardment crew members

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In the assignment of students to the three courses, an unusual screening process had to be followed, necessitated by the physical dimensions of the Sperry ball turret, installed on the B-24 airplane. It had been found that men taller than 5 feet 5 inches and heavier than 150 pounds could not operate this type of turret satisfactorily.[31] Therefore, 36 per cent of the students whose weight and height were closest to this limit were assigned to the B-24 course, the next 36 per cent to the B-17 course, and all the others to the medium bombardment course.[32]

When it was determined, in the autumn of 1944, that the aircrew of the new very heavy bomber, the B-29, would include an armorer-gunner, the Training Command directed that the scope of armament training at Lowry be expanded to offer instruction for these men before they entered the flexible gunnery schools.[33] On the basis of this, a B-29 course was begun in January 1945 which called for 42 days of training. During the first 20 days the instruction covered the same material given in the B-17, B-24, and medium bombardment armament courses. The latter 22 days covered material from the remote control turret course.[34]

The AAF expected that its other type of very heavy bomber, the B-32, would also require the services of an armorer-gunner. During the latter months of 1944 and early 1945 Headquarters, AAF continued to send directives and suggestions to Lowry to prepare a course of this type, and even set a number of starting dates. The Lowry officials went to great pains to get ready, drawing up a syllabus and coaching instructors;

by December 1944 they were in a position to begin the course as soon as B-32 equipment arrived.[35]

All these plans were scrapped as a result of a conference held at Headquarters, AAF between officials of the Twentieth Air Force and the AC/AS Training early in February 1945. It was agreed there that the operation of the guns of B-29 and B-32 planes so occupied the time of a gunner that he did not have time to perform maintenance work on such equipment as armament; therefore, it seemed inadvisable to give him armament training. Moreover, the requirement for gunners with armament training on B-17, B-24, and medium bombardment crews had now been completely met.[36] Therefore, during April the B-29, B-17, B-24, and medium bombardment courses were all discontinued, and plans for the B-32 course were dropped.[37]

At this time Headquarters, AAF set as a goal for the Lowry school a type of basic armament training which the school authorities had been urging since April 1943—a long, comprehensive, thorough course, covering all types of aircraft armament and given at an unhurried pace. Such a "token" course would keep intact a small corps of experienced instructor personnel and equipment, and by use of the "block system"[38] make it possible for operational air forces to obtain instruction on part or all of the course for their assigned personnel.[39] The reorganized course, with a curriculum calling for 20 weeks of instruction, was begun during the summer of 1945, with a new class of five men entering every two weeks.[40] The course was as follows:

Subject	Days
Technical Orders and Supply	2
Chemical Warfare	3
Explosives and Ammunition	1
Bombs, Fuzes, and Aircraft Rockets	4
Shop Practice and Basic Electricity	10
Bomb Racks	15
Weapons (small arms, machine guns, aircraft cannon)	30
Fixed and Flexible Gun Mounts	1
Sights, Cameras, and Harmonization	9
Turrets (locally and remotely controlled turrets and gun mounts)	20
Tow Targets, Windlasses, and Skeet	1
Final Phase Testing	4

With this curriculum, the Lowry school undertook to train the armorers necessary to maintain the "Postwar Air Force."

Chapter IV

POWER OPERATED GUN TURRET AND REMOTE CONTROL TURRET COURSES

The courses dealing with the maintenance of power operated gun turret and remote control turret (central fire control) systems are of peculiar interest because they were the only regularly given courses in the armament field exclusively concerned with equipment which came into use while World War II was being fought.

Power Operated Gun Turret Courses

First and second echelon. In the summer of 1940, reports reached Lt. Col. Early E.W. Duncan, Commandant of Lowry Field, that the RAF was experiencing considerable success in the use of power operated gun turrets and that the Air Corps was contemplating their installation on its bombers. These reports led Colonel Duncan to propose to the Chief of the Air Corps that steps be taken to establish a course in the maintenance of this type of equipment. Such training, he suggested, should be given not to all aircraft armorers, but only to men who would be concerned with the maintenance and operation of such equipment.[1]

For six months no action was taken on his idea. Not until 5 December 1940 did the Air Corps make any definite plans for the procurement and installation of power operated gun turrets in its bombers.[2] Not until 27 March 1941 did a board composed of an officer from Lowry and one from Wright Field meet at Wright Field to formulate recommendations as to

how such a course should be established. Their chief proposals were:[3]

(1) The course should be completely distinct from the armament course.
(2) It should be approximately 16 weeks in duration.
(3) It should graduate approximately 40 students each month.
(4) Because turrets were extremely complicated equipment, great care should be exercised in the selection of students.
(5) Men already assigned to tactical units should not be sent to Lowry to take the course. Assigned personnel should receive instruction from civilian representatives of the factories manufacturing the turrets installed in the airplane used by their squadrons.
(6) In preparation for the course, eight Lowry enlisted instructors were to be sent to the four factories making the turrets adopted by the Air Corps as follows:

2 instructors to General Electric for 6 weeks' instruction
2 instructors to Sperry for 6 weeks' instruction
2 instructors to Bendix for 4 weeks' instruction
2 instructors to Consolidated for 2 weeks' instruction

(7) As it did not seem likely that more than one officer could be spared for the course, it would be necessary that he take training at each of the four factories. No estimate was made as to the amount of time this would require.
(8) The course should start just as soon as turrets necessary for instructional purposes had reached Lowry and the instructors had returned from their training at the factories.

With a single important exception, all of the board's recommendations were approved by the Training and Operations Division of the Office of Chief of the Air Corps. Owing to the critical times, Training and Operations felt that 16 weeks was too long a period for such a course; eight would be enough.[4]

Capt. William F. Day of Lowry was detailed to make arrangements for training eight instructors and himself at the manufacturing plants.

This was not easy to accomplish, for a complete set of the turret equipment was hard to come by, even at the factories. However, the manufacturers went out of their way to cooperate, and by the middle of September all eight instructors had had some sort of factory training.[5] During the following winter Captain Day and his instructor corps paid second visits to the plants so as to keep abreast of the technical advances being made in this rapidly developing field.[6]

Captain Day, who subsequently became supervisor of the Power Turret Division at Lowry, has left a vivid description of the conditions which prevailed when the new course was starting. "On September 15, 1941," he wrote later, "this school, armed with six inexperienced turret instructors and no equipment, prepared to meet thirty-three (33) students [who had been sent to it by Air Corps tactical organizations]. The instructors had purposely avoided mailing a schedule of instruction [to the tactical units], because they did not know the type of student who would appear, nor did they have any past experience as a base on which to allocate time of study on a given subject."[7]

It required only a few weeks of experimentation to convince the Lowry officials that the Office of Chief of the Air Corps had made a mistake in setting the length of the course at eight weeks. On 7 October they requested permission to extend it to 12 weeks;[8] three weeks later the OCAC granted permission for a "temporary extension."[9]

From the outset the school was handicapped by the "pitiful lack of sufficient power turret equipment." Some Martin turrets trickled in during the first month the school was giving instruction, but six months passed before any Bendix or Consolidated equipment arrived. "The Bendix instructors," Captain Day reported, "were forced to use the limited supply of blueprints, diagrams, and facts that were available. In short, the instructors were forced to teach a 'blackboard' turret for more than six (6) months. This tended to confuse the instructors as well as the students as only two of the instructors had actually seen and operated the Bendix. The students rapidly lost interest in the 'blackboard' turret . . . ."[10]

The school had some equipment which was, in the words of Captain Day, "of great value, but only insofar as it was better than nothing. For instance, the Sperry sight is fourteen inches square, and only four instructors and one student can study it with semi-effective results. This acute shortage of sights not only lengthens our period of study, but, in addition, fails to give students a chance to 'tear it down' and gain a working knowledge."[11]

The turret course was still in this embryonic state when the attack on Pearl Harbor plunged the nation into war. On 8 December 1941 the Power Turret Division was directed by the Technical Training Command that the course was to be shortened from[12] to eight weeks, with a new class of 80 men entering each four weeks.[12]

Under this new schedule, which went into effect on 13 December, instruction time was allotted as follows:

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Phase		Time
I.	Bendix Turrets Introductory material; Bendix lower turret; and Bendix upper turret.	2 weeks
II.	Sperry Turrets Sperry sights: maintenance, installation, and harmonization, 9 days; caliber .50 machine gun, 1 day; Sperry upper local turret; Sperry lower ball turret; and Sperry lower ball retractable turret.	4 weeks
III.	Martin Turret	8 days
IV.	Consolidated Tail Turret	4 days

At the start of the first phase, considerable time was devoted to explanations of the importance of turrets in bombardment warfare. This was done because it had been found that some students did not apply themselves to the course, declaring that they were not interested in the subject.[13]

Early in 1943, the curriculum was reorganized, with the four weeks devoted to Sperry equipment being given as the first phase and the two-week period on Bendix turrets becoming the last phase. Under this new arrangement, most of the first day of the course continued to be devoted to the caliber .50 machine gun. Experience had indicated that a "practical knowledge of machine guns" was so important to turret maintenance men in the field that this instruction was repeated on the first day of the Martin course, the second phase under the varied curriculum.[14]

The course was lengthened to nine weeks the following 13 September so that a week's instruction could be given on two new types

of equipment, the Bendix lower chin turret and the Emerson nose turret.[15] The Lowry officials had made elaborate, if not completely successful preparations for these new phases. As soon as they heard that the two new types of turrets were being installed in AAF bombers, they undertook to obtain some for the school; but as operational units had priority, none could be procured until instruction on them had commenced at Lowry. The school did succeed in arranging to have several enlisted instructors visit modification centers, the Armament Training School at Indianapolis, and the factory of the Emerson company to obtain data upon which to plan the course.[16]

When in the summer of 1943 the Training Command put into practice a policy of having all technical courses organized into "blocks of instruction" so that students on detached service from tactical organizations might take only the instruction which they would use when they returned to their units, it became necessary to rearrange the syllabus of the turret course more completely than was the case in other armament courses. The revision went into effect on 15 October, at which time the course was renamed "Power Operated Turrets and Gun Sight Specialist / Mechanic Course" out of respect to the highly important sights used in connection with the turrets. Under this revision, the instruction was arranged as follows:

Block	Subject	Days
#1	Caliber .50 Machine Gun	3
#2	Consolidated Turret	3
#3	Sperry Upper Local Turret	6
#4	Sperry Local Ball Turret	6
#5	Sperry Automatic Computing Sight	12
#6	Electricity	6
#7	Martin Turret	6
#8	Emerson Turret	6
#9	Bendix Turret	6

Under this system, a student from a unit operating:

B-17 F	planes	would	take	only	Blocks	# 1, 3, 4 and 5;
B-17 G	"	"	"	"	"	# 1, 3, 4, 5, 6, and 9;
B-24 D	"	"	"	"	"	# 1, 2, 6, and 7;
B-24 E	"	"	"	"	"	# 1, 2, 4, 5, 6, and 7;
B-24 G&H	"	"	"	"	"	# 1, 2, 4, 5, 6, 7, and 9;
B-25 D	"	"	"	"	"	# 1, 6, and 9;
B-25 G	"	"	"	"	"	# 1, 6, and 9;
B-26	"	"	"	"	"	# 1, 6, and 7

Unassigned students would take the entire course as previously.[17]

The K-series of gun sights caused the Lowry officials a number of problems during the winter of 1943-44. The first case arose when a copy of AAF Training Standard No. 80-52, prepared by Headquarters, AAF and dated 20 September 1943, reached Lowry early in October. An analysis of the standard convinced the school officials that their course prepared students to meet all the specifications except for the maintenance of the K-8, K-9, K-10, and K-11 computing gun sights, the Crocker-Wheeler and Curtiss-Wright turrets, and the Bell gun mount. These were not being taught because the school had never received a directive to teach them, and did not possess any of the equipment in question.[18]

As a matter of fact, the Lowry officials had undertaken to anticipate the need for training on the K-8 several months earlier, but without success. In July one instructor was sent to the Fairchild factory to study the sight, and three were sent the following October. These units, which were used in conjunction with the Martin turret, were complex in design and operated on the electronic principle. It would be necessary

to devote two weeks to teach them adequately. But for some time the school could not obtain permission to lengthen the turret course to 11 weeks or to set up a special two-week K-3 sight course.[19]

Early in December two Sperry K-11 gun sights arrived at Lowry. The school had no instructors qualified to teach their maintenance. They remained idle several months while Lowry made an effort to obtain civilian instructors from the Sperry Gyroscope Company, and finally sent five of its own instructors to the Sperry factory.[20]

By early 1944 it had become apparent that in the future the AAF would center its attention on very heavy bombardment. Inasmuch as this type of aircraft employed a central fire control system, with certain similarities to, as well as certain important differences from, the power operated turret systems, some modification of AAF training in this field appeared necessary. On 16 February 1944 the Training Command issued a directive that the "Power Turret and Gun Sight Specialist Mechanic Course" be changed into a "Pre-central Fire Control Course" which would act as a feeder to a new "Central Fire Control Course."[21]

The Lowry officials protested that of the nine weeks of work they offered in their Power Turret and Gun Sight Specialist Mechanic Course, only the first three covered material which would be useful to men destined to maintain central fire control systems. These were the phases devoted to the caliber .50 machine gun, basic electricity, and electricity as it applied to the amplidyne system. Therefore, they thought, only these three phases should be given to central fire control students.[22]

"The Central Station Fire Control System," the Training Command wrote back, "is still considered to be in the experimental stages, since it has not yet been proven in combat." There was considerable possibility that it might have to be scrapped and a more conventional turret system installed. If this should prove necessary, the Training Board added, it did not wish to have to re-train the men after the change was made. Therefore, it directed, men should be given complete instruction on both power turrets and the central fire control system, although obviously repetitious material might be eliminated.[23]

With obvious reluctance, the Lowry and ATC authorities complied with the order, revising the Power Turret Gun Sight Specialist Mechanic Course so that it would serve as a Pre-central Fire Control Course. Beginning on 10 April, the seven weeks of instruction was arranged as follows:

Subject	Days
Basic Electricity	6
Machine Guns and Martin Turret	6
Emerson Turret	6
Sperry Gun Sights (K-3, K-6)	12
Sperry Turrets	12
TOTAL	42

It will be observed that to reduce the length of the course from nine to seven weeks, instruction on Consolidated and Bendix turrets was omitted. Basic Electricity was moved to the beginning of the course because it was felt that this material was fundamental to all turret instruction.[24]

RESTRICTED SECURITY INFORMATION

After this syllabus had been in use just about a month, the Lowry authorities returned to their earlier position that it wasted the student's time. Now they offered a rebuttal to the Training Command's objection that if there was a separate central fire control course delay in training might result, in the event that the central fire control system were scrapped and regular power turrets substituted in very heavy bombers--it would take only seven weeks to retrain Central Fire Control Equipment (CFCE) men, less time than would be required to modify the airplanes themselves.[25] On May 20 the school officials were notified that beginning two days later they might substitute a three-week course in basic electricity and the caliber .50 machine gun for the seven-week course for men who were going to take a CFCE course.[26] The three-week Pre-central Fire Control Course was consolidated with the Remote Control Turret courses on 21 August 1944. Its vicissitudes after that date are discussed in the section on Remote Control Turret (RCT) courses.

This left Lowry officials still concerned about the students destined to maintain the conventional type of power operated turrets. In its streamlined seven-week form, the course neglected many types of turrets and gun sights which its graduates might later be called upon to service. To correct this, late in May 1944 the Lowry authorities recommended that the course be extended to 12 weeks, to include instruction on three types of equipment not previously taught, but which had come into general use--the Sperry gun sights K-9 and K-11, and the Motor Products turret wheel. It also provided for a full week of instruction on machine guns, instead of the one-day period, which Lowry

believed to be grossly inadequate. [27]

Twelve weeks was too long, Headquarters, AAF ruled when the request reached it; 10 weeks was all that could be allowed. In this 10-week period all the equipment proposed by Lowry Field, plus the A-13 gun sight, must be taught: [28]

Machine Guns	3 days
Basic electricity	1 week
Amplidynes	3 days
Martin Turret	1 day
Emerson Turret	1 week
Bendix Turret (upper and chin)	1 week
Consolidated and Motor Products Turrets	1 week
Sperry Turret (upper and lower)	1 week
Sperry Gun sights (A-3, A-4, A-9, A-10, A-11, A-13)	3 weeks

This schedule was put into effect with the class entering on 3 July 1944. [29]

From the middle of 1944 to the end of the war the school officials kept increasing the length of the course constantly--to 11 weeks in March 1945, to 13 weeks in May. These additions were made primarily to permit the incorporation of material on new types of equipment of which the AAF was making use--the Sperry A-17 and A-17A, A-14 and A-15 turrets sights; the Sperry Upper Turret Type A-10, equipped with M1/AFC-5. Not all the curriculum changes involved additions, however, for equipment which had been superseded or found ineffectual in use was dropped. [30] By V-J Day the course had been lengthened to 16 weeks, and was operating on a token basis with only a few men in each class: [31]

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Subject	Days
Caliber .50 Machine Gun	3
Basic Electricity	7
Amplidyne	4
Martin Turret	6
Emerson Turret (A-15 and A-15A)	6
Bendix Turret (upper and chin)	6
Motor Products Type Turrets and Bell Gun Mounts	6
Sperry Turrets (upper, lower, lower retractable, nose, and tail)	12
"K" series sights (K-3, K-4, K-10, K-11, K-13, K-14, and K-15 types)	30

Third and fourth echelon. In the spring of 1942, about the time that the first and second echelon power turret course was getting under way at Lowry Field, the Field Services Division at Headquarters, AAF became concerned about the need for training on a third and fourth echelon level. Most of this work was to be performed in the depots and subdepots of the Air Service Command (ASC) by both civilian and military personnel. At its direction a 10-week course in first, second, third, and fourth echelon maintenance was established at the AAF Storage Depot, State Fair Grounds, Indianapolis, Ind., an installation of the Air Service Command. The course was operated in two shifts, one for military personnel and one for civilian employees. As far as practicable, civilian instructors taught civilians, while enlisted instructors taught the military personnel. The principal features of the course were:

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Subject	Weeks
I. Basic Fundamentals Mathematics, electricity, hydraulics	2

[redacted]

Subject--Cont'd.	Weeks--Contd.
II. Martin Turret (electrically operated upper) and Consolidated (hydraulically operated tail) Turret	2
III. Bendix Turrets (electrically operated upper and lower)	2
IV. Sperry Products Sperry sight, upper local and local ball turrets	4

Originally all personnel at the school--military and civilian, instructor and student--had been furnished by the AGC, the organization which would use third and fourth echelon maintenance personnel in depots and subdepots. Although the ASC exercised a certain degree of selectivity in assigning students to the course, the school authorities found that the students did not always have the knowledge of mathematics, elementary electricity, elementary hydraulics, and simple soldering and wiring methods which they considered indispensable for turret maintenance work. To cover this material they had incorporated the preliminary two-week phase known as "Basic Fundamentals."[33]

When the school was transferred to the Technical Training Command and its name changed to Armament Training Center No. 3, on 1 February 1943, the TTC assumed the responsibility of providing the enlisted students for the courses. The TTC decided that hereafter certain percentages of the graduates of the Lowry basic armament course would be selected for the Indianapolis course. The use of the Lowry armament course as a "feeder" for the Indianapolis turret course inevitably

produced a number of problems of coordination and friction between the two schools.

The first arose from a desire to avoid duplication between the two courses. During this period, it will be recalled, the last three weeks of the Lowry armament course were devoted to study of power operated turrets on a familiarization level. The Indianapolis school urged that its quota of students be sent to it before taking this phase—in other words, three weeks before graduating from the Lowry course. The Lowry officials protested that this would lead to the loss to the AAF of many potentially fine armorers. If a man had completed the Lowry course but was eliminated from the Indianapolis course, he was at least qualified for service as a basic armorer. On the other hand, if he left Lowry before he had graduated and then failed the turret course, he would be qualified neither as a basic armorer nor as a turret man. The ITC ruled in favor of the Indianapolis school, and the men accordingly were sent on to the turret course three weeks before graduating from Lowry.

The second source of friction was the type of men which Lowry sent to Indianapolis. In April 1943, after five classes had been received, the officials of the Indianapolis school protested that, on the average, being the quality of the men/sent them was far below that of those previously furnished by the Air Service Command. Comparatively few had had any mechanical experience or training before entering Lowry. An analysis of the fifth class, they declared, showed that seven of the 24 men had not graduated from high school, and five had had no previous mechanical

training. These shortcomings were felt particularly during the course on the Martin turret. This turret employed the amplidyne system; to master it a man had to have had "the equivalent of a full college course in electricity." It had been understood that only top-ranking students were to be sent to Indianapolis. However, the school authorities declared, "We are inclined to believe that these men are run of the course, and are selected alphabetically only."[35]

In defending themselves the Lowry officials pointed out that, acting on directives from higher authority, they were sifting their armament students into six categories when making assignments. Four of these types of assignments had been given higher priority than the Indianapolis school. They promised that hereafter they would select students for Indianapolis from the fourth as well as the fifth categories.[36] The Indianapolis authorities none too happily reconciled themselves to this situation. Their faculty board increased the rate of eliminations, although trying always to give the benefit of the doubt to men who were slow in grasping the subject matter, but who tried hard.[37]

The increased use throughout the AAF of two pieces of turret equipment made it necessary to extend the course by one week during September 1943. The first was the Bell H-6 gun mount. Three days were devoted to familiarization training, complete dismantling, and some practice in trouble shooting. Time for this instruction was taken from the phase covering Sperry turrets, which had to be reduced from three to two and one-half weeks.[38]

The other was the Emerson turret, which resembled the Consolidated

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turret in many respects but used electrical rather than hydraulic power, and required a full week of instruction.[39]

The problem of friction between the two schools ended when, as part of an AAF policy of centralizing all technical training, the Indianapolis school was ordered closed as of 31 January 1944, and all its military instructor personnel moved to Lowry.

There was a delay of several months in getting instruction on the third and fourth echelon level under way at the new location. The Lowry authorities protested that the Sperry sights were too "diversified" in nature to include them in the same course with turrets, and proposed that two separate courses be given. This notion was rejected by the Training Command, however,[40] and an eight-week Power Operated Turret and Gun Sight Repairman Course was begun on 15 May 1944. Classes were small--usually four enlisted men to a group--selected from recent graduates of Lowry's first and second echelon course. Enlisted men sent by depots and subdepots on detached service were also accommodated from time to time.[41] Subject matter covered was:

Subject	Weeks
Basic Fundamentals (tools, shop practice, repair of plexiglass, etc.)	1
Consolidated Turret	1
Bendix Turret	1
Martin Turret	1
Emerson Turret	1
Sperry Turret	1
Sperry Sights	1½

It will be observed that although the new course at the outset was two weeks shorter than it had been at Indianapolis, it included

instruction on the Emerson turret, which had not been given previously. This arrangement was soon recognized as being unsatisfactory, and the course had to be lengthened to permit more thorough instruction as well as the addition of new types of AAF turrets and sights--from 8, to 10, to 14 weeks.[42] By V-J Day the course was being operated on a token basis, 10 students in a class, and classes 16 weeks in length:[43]

Subject	Days
Basic Shop Practices	8
Motor Products Type Turrets	6
Bendix Turrets (upper and chin)	6
Martin Turret	7
Emerson Turret (A-15 and A-15A)	6
Sperry Turrets (upper, lower, and lower-retractable)	12
"K" Series Sights (K-3, K-4, K-10, K-11, K-13, K-14, and K-15 types)	35

Remote Control Turret Courses

First and second echelon. During 1942 the AAF started making plans to train men to operate a radically different type of airplane--the very heavy bomber, the B-29. The armament on this plane was to be unique--five turrets which might be controlled by any one of five operators. Two firms were making equipment for it at that time--the General Electric Company and the Sperry Company, although it was expected that for the time being only that manufactured by General Electric would be used.

The Lowry school was told to proceed with plans for training on the central fire control equipment (CFCE) in January 1943. The school authorities selected instructors experienced in teaching its Power Operated

Turrets Course to provide an initial instructional cadre. Groups of them were sent to the General Electric factory at Schenectady, N.Y., and to the Boeing Aircraft plant at Wichita, Kans., for short periods of intensive training. In addition, the General Electric sent three of its employees to Lowry for a period to teach instructors there.

Because of the complex nature of CFCS, AAF training officials realized that enlisted men of an unusually high quality would have to be selected for the student body. The first and second echelon FOCT course would provide an excellent background for the new course, they felt; hence the former was to be considered a prerequisite for the latter. But only the "cream" of the FOCT classes were to be selected: they must have an AGCT score of 120, a grade of 120 in the mechanical movement test, and a grade of 120 in the Army mathematics test—and in addition, an understanding of the nature of radio, electricity, and mechanics. Since most of the students who possessed these qualifications were already assigned, the school found it difficult to find enough men to meet the quotas. Because of the high priority of the B-29 project, basic classification centers were warned that they must scrupulously fill all quotas for the course.

The number of men trained in CFCS was gauged closely to the changing requirements of the XX Bomber Command, which in turn were controlled by the production rate of the B-29 factories. At the outset a new class of 24 men was entered every two weeks. The length of the course was likewise tentative; when it started on 1 March 1943 it ran

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for 16 weeks:

Subject	Weeks
Basic Electricity	2
Soldering: Use of Tools; Rotating Machines; Gun Chargers	2
Vacuum Tubes; Selsyns Function; Servo-amplifier	2
Selsyn-zeroing; Follow-up System; Sighting Stations; Basic B-29 Wiring Diagram	2
B-29 Wiring Diagrams	2
B-29 Malfunctions	4
Malfuctions; Harmonization; Test Operation	2

During the last two weeks of the course the students worked on a mock-up of the B-29 under simulated warfare conditions. These included sudden gas drills, exercises in slit-trench digging, inadequate lighting, rain, bombing and strafing attacks, and snow.

During its first year the size of the classes was increased enormously--one class which entered in August 1943 numbered 184 members. Even more of a problem from an administrative point of view was the fact that the size of the classes fluctuated greatly. Owing to the difficulty of the subject matter, the elimination rate ran high--as

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high as 18 per cent.

These mounting demands and high elimination rates soon made it impossible for the Lowry officials to find enough qualified students among the graduating classes of the power operated turret courses. To provide the needed numbers, additional sources were tapped: the Lowry Field basic armament course; the school at Buckley (during the period the armament course was being given there); and Truax, Scott, and Sioux Falls,

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where courses in radio and electronics were conducted. To meet their quotas, some of the schools sent men whose AGCT scores were below 120. The failure of a large percentage of these caused the Lowry officials to screen incoming students carefully and to accept only as many below the 120 mark as was absolutely necessary. Students who professed no interest in the course were also eliminated, so far as possible, by screening.[46]

During 1944 the course underwent a series of revisions designed to obviate the necessity of students having an armament, radio, or electronics background to benefit from the training. This was accomplished first by the institution as a preliminary course of a three-week Pre-central Fire Control Course consisting of instruction in basic electricity and the caliber .50 machine gun. Then, beginning in August 1944, the Central Fire Control Course (which was now coming to be called the Remote Control Turret Mechanic Course) was lengthened to 18 weeks to permit the incorporation of the Pre-central Fire Control Course material. About a year later the course was again lengthened, this time to 20 weeks:[47]

Subject	Days
Caliber .50 Machine Gun	5
Principles of Electricity Applied to RCT Drive Units	20
Servo-Amplifier	10
Basic System	20
Wiring Diagrams and Auxiliary Equipment	20
Malfunctions	20
Inspection and Maintenance	5

Third and fourth echelon. In November 1942—three months before Lowry Field started its first and second echelon GFCI course—the AAF

started a four-week course in depot overhaul at the Armament Training School at Indianapolis. The school chose graduates from each of its 48 classes in power operated gun turret depot overhaul for this training.

Two major difficulties were experienced in conducting the course. One grew out of the fact that a four-week period was much too short to cover adequately the difficult subject matter involved. This was aggravated by the manner in which the school selected students: men receiving top grades in the Power Operated Gun Turret Depot Overhaul course were assigned to OFCS training even though they had no particular interest in OFCS and in many cases—so it was charged—had obtained their high grades "through dubious means." Instructors at the school had the feeling that as a result many men were graduated from the course who were not actually qualified. Another difficulty was that the school did not have enough or the right kind of equipment. It had four sets of P-61 equipment—probably enough for the four-to-eight-student groups which composed the first 49 classes, but far too few for the 30-to-40-man classes which followed.

The needs of the AAC for increased numbers of maintenance personnel and the policy of concentrating depot overhaul training at Lowry brought a drastic revision early in 1944. The school at Indianapolis was closed down, and Lowry was directed to start a new course, to last 12 weeks, on the third and fourth echelon level. The General Electric Company dispatched a representative to Lowry to assist the school authorities 50 in setting up the new course. New classes of seven men each, graduates of the Lowry Power Operated Gun Turrets Repairman Course, were

entered weekly. Lowry had the benefit of a quantity and variety of equipment which the Indianapolis school had never enjoyed.[51]

One part of the CFCE--or remote control turret system--which created considerable maintenance problems was the computer. Most of the time of the Lowry course was devoted to explanation of this computer.[52] In addition, the General Electric Company conducted at its Schenectady factory a six-week course in fourth echelon maintenance of the computer for key maintenance personnel who had graduated from the Lowry first and second echelon remote control turret course.[53]

Chapter V

BOMBSIGHT MAINTENANCE COURSE

The Augmentation Program, first of the Air Corps expansion programs, provided that between March 1939 and June 1940 an average of 12 bombsight mechanics was to be graduated from the Air Corps technical schools each month.[1] Responsibility for meeting this goal fell upon the school at Lowry Field, which during the entire calendar year of 1938 had graduated a total of only 24 bombsight men;[2] but by stretching material, personnel, and school housing facilities, Lowry was able nearly to achieve the pace which the higher authorities had set for it. By October 1939 it was entering 12 students a month; by November 1940 it was matriculating well over 24 students a month.[3]

This record is the more impressive when one considers the various handicaps created by changes in curriculum, shortages of personnel and equipment, and other difficulties under which the Lowry authorities had to labor. In late 1939 and early 1940 they had substituted instruction on the new Sperry C-1 sight for the now outmoded Sperry A-1 sight; they also began giving instruction on the new automatic pilots used in connection with Sperry and Norden sights. Although those pilots required considerable explanation, it was believed that the length of the course ought not to be extended beyond the 12-week period already allotted to it. As a consequence, the other subject matter in the curriculum had to be condensed to make room for this new material,

and the course as a whole became correspondingly more difficult.[4]

In this form, however, the course pleased neither the Lowry officials nor the Air Corps officials in Washington. Both agreed that 12 weeks was too short a period for the amount of material the course attempted to cover. As the Director of the Lowry Armament Department pointed out, the Navy was devoting four months to instruction on the Norden sight and its associated pilot alone, whereas the Air Corps was giving 12 weeks of training on the Norden sight and its pilot plus the Sperry sight and its pilot; and the results in the Air Corps were not considered satisfactory by the school authorities.

One possible solution was to train students only on the particular type of pilot and sight they were to be assigned to maintain. The drawback to this, as expressed by the Office of the Chief of Air Corps, was that enlisted personnel were frequently moved from squadron to squadron, and that changes were often made in the equipment used by tactical units. Therefore, the service would be severely handicapped if its personnel were capable of maintaining only one type of equipment. Another solution, which was favored by the Lowry authorities, was to lengthen the course to four months, devoting three months to the Norden sight and pilot, as well as to the mathematical and scientific principles necessary to its understanding, and one month to the Sperry sight and pilot. Admittedly this plan had one shortcoming: it would require one-third more time, one-third more space, and three additional instructors.[5] In forwarding these observations to the Chief of the Air Corps, the Office of the Commandant, Chanute Field,

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added:

It is believed that instruction on Sperry equipment should be as accurate and as thorough as that given for the Norden Bombsight, even though fewer sets of Sperry equipment are available to the Service. It is the experience of the Armament Branch that the Sperry sight is the more difficult of the two types to teach and that instruction is simplified if the course in Sperry follows Norden.

Out of these discussions a new curriculum was developed which
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was put into effect 1 July 1940:

Subject	Hours
Theory Problems	44
Camera Obscura Problems	4
Elementary Electricity	16
Principles of Gyroscope	16
Disassembly of Norden M-1 Bombsight by Instructor	16
Clock, Theory and Maintenance	12
Trainer Wiring, Theory and Practical	12
Complete Disassembly of M-1 by Instructor	16
M-series Sight, Operation by Trainer	24
Norden Automatic Flight Control Equipment (A.F.C.E.) Classroom Work; Study of Units and Their Functions	88
A.F.C.E. Maintenance and Inspection of Equipment in Plane	16
A.F.C.E. Adjustment in Flight	16
M-3 Disassembly by Students	16
M-3 Maintenance and Cleaning	16
M-4 Maintenance and Cleaning	16
M-3 Calibration by Instructor, Students Observing, Taking Notes, and Practicing Adjustments	16
M-3 Calibration by Students	64
M-4 Calibration by Students	64
M- Series Summary	8
Sperry O-1 General Study of Units and Their Functions	64
O-1 Calibration by Instructor, Students Observing and Practicing Adjustments	8
O-1 Calibration by Students	32
O-1 Trainer Operation	24
O-1 Installation in Airplane	4
Flying (dry runs)	12
O-1 Summary	16
TOTAL	540

Late in November 1940 the Lowry authorities recognized that the Sperry C-1 sight was no longer being used in the Air Corps, and discontinued giving instruction on it.[8] The dropping of this equipment permitted them to revise the syllabus to answer a criticism that had frequently been made that A.A.C.S. equipment was so complicated that only superior students could master it in two weeks. With the omission of Sperry material, the length of the course was made 14 weeks, with four weeks—the sixth to ninth inclusive—devoted to A.A.C.S.

Under this revision, during the eighth and ninth weeks 24 hours were designated "flying time." Although the bombsight maintenance man was not expected to fly in the normal course of his work, this feature was incorporated because it was felt that he would have a keener appreciation of the importance of his work if he had such experience. The school officials desired to make the final flight a sort of examination in which the student would be called upon to demonstrate his ability to adjust instruments in the air as well as on the ground. It was impossible to achieve such a goal because of the shortage of airplanes and flying personnel at Lowry. In actual practice, only one-half of an eight-man class could fly at one time, with the result that only 12 hours were actually spent on the aerial instruction of each student.[9]

As the pace of Air Corps expansion quickened in the autumn of 1941, increasing numbers of men who had had no previous experience in bombsight work in tactical units arrived at Lowry to take the course.

Recognizing that the course was too short and limited in scope to turn a novice into an expert, the Director of the Armament Department gave an order that thereafter the fact that a man was not fully qualified was to be entered on his qualification card when he was graduated.[10]

The entrance of the United States into World War II brought a reduction in the calendar length of the course from 14 to 12 weeks. Actually, the curriculum remained substantially unchanged, and as the school operated on a six- rather than a five-day week after 13 December, the number of training hours was increased from 560 to 576.[11]

By the summer of 1942 production on the new Sperry S-1 bombsight and A-5 automatic pilot was well under way; it was planned ultimately to install them on 50 per cent of all new bombardment planes. To be forearmed for the expected demand, training on the Sperry instruments was inaugurated on 20 July.[12] At first all students were given eight weeks of first echelon training in both Sperry and Norden equipment, while certain ones continued for an additional four weeks of second echelon training on either Sperry or Norden equipment.[13]

This arrangement, it soon was realized, was far from satisfactory. Tactical units expected all their mechanics to be able to perform at least second echelon maintenance. Thus, beginning 10 October 1942 all bombsight mechanics were given a 12-week course which covered second echelon maintenance of either Sperry or Norden equipment. All students took the first three phases:

First Week, 42 Hours
Mathematics; Vacuum Bombs; TF 1-277 "Theory of Bombing"; Bombing Problems; Cross Trail; D-8 Sight.

Second Week, 42 Hours
Physics of Gyroscopes; DC Electricity.

Third Week, 42 Hours
AC Electricity and Vacuum Tubes.

At the end of this period, half of the class was assigned to nine weeks of further study on Norden equipment, the other half to an equal period on Sperry equipment. The schedule for Norden students was:[14]

Fourth Week, 42 Hours
Course and Range Mechanisms, T-Series Bombsight; Partial Disassembly; and Wire Diagrams.

Fifth Week, 42 Hours
Partial Disassembly of Gate End; Telescope Motor; Wiring Diagram; Disassembly of Sight; Mechanical Operation and Disassembly of Stabilizer; Maintenance of T-3; Preflight, Daily, 15 Hours; 15-day Checks of Stabilizer Gyro; Maintenance and Operation of D-8 Sight.

Sixth Week, 42 Hours
Changes between T-3 and T-6; Familiarization, Precautions in Handling, Interchangeability of Units, Maintenance Covered by Students and Instructor; Operation, Wiring and Oiling of the A.F.C.S.; Field Check of the Gate End; Assembly of Low-Altitude Attachment.

Seventh Week, 42 Hours
Calibration; Use of Synchronizing Beam; Practical Examination.

Eighth Week, 42 Hours
Free Motion Tune; Field Calibration; Trouble Shooting.

Ninth Week, 42 Hours
Flight and Operation of Control Services; Stabilized Flight; A.F.C.S.; Operation of A.F.C.S. Lock-up Tests; Wheatstone Bridges and Servo Units; Inspection and Installation of Equipment in Airplanes.

Tenth Week, 42 Hours
Ground and Flight Adjustments; Inspection and Maintenance of A.F.C.S. in Airplanes; Wiring Diagrams; Practical Examination.

Eleventh Week, 42 Hours
A.F.C.E. Lock-up Operation; Trigger Circuits; Inspection, Installation, and Removal of Units; Ground Adjustments; Practical Examination.

Twelfth Week, 42 Hours
Ground Adjustments; Flying and Air Adjustments; Inspections; Practical Examination.

The schedule for Sperry students after the first three weeks was:

Fourth Week, 42 Hours
Course and Range Mechanisms, S-1 Sight; Partial Disassembly; Wiring Diagram.

Fifth Week, 42 Hours
Schematic Drawings, Operation and Mechanics of S-1 Sight; Checking Sight for Proper Calibration and Operation; Practical Examination.

Sixth Week, 42 Hours
Calibrations and Operation; Inspections; Wiring Diagrams; Routine Maintenance; Practical Examination.

Seventh Week, 42 Hours
Trainer Operation; Air Operation; Disassembly, Precession Runs and Pendulum Balance; Practical Examination.

Eighth Week, 42 Hours
Sub-assembly Adjustment; Reassembly and Adjustment; Maintenance, Oiling, and Storage; Electrical Check and Trouble Shooting; Practical Examination.

Ninth Week, 42 Hours
Azimuth Unit and Control Panel of A-5 Pilot; Amplifier; Vertical Unit; Block Diagram; Lock-up; Practical Examination.

Tenth Week, 42 Hours
Aileron Control Operation and Adjustment; Elevator Control, Including Trim Tabs and Constant Altitude Control; Preflight Inspection and Routine Maintenance; Trouble Shooting; Practical Examination.

Eleventh Week, 42 Hours
Maintenance and Adjustment of Azimuth Unit and Follow-up Amplifier; Disassembly, Maintenance, and Adjustment of Vertical Gyro Unit, Servo Unit, Constant Altitude Control Unit, Follow-up Amplifier, and Trim Tab Control Unit; Practical Examination.

Twelfth Week, 48 Hours
Ground Check and Adjustment; Aerial Flying Adjustments; Trouble Shooting and Maintenance; Practical Examination.

Of the total hours, students still spent only 12 hours in the air.[15]

Another drastic revision of the curriculum took place in the summer of 1943, one designed in response to a curious combination of new demands. Prominent among them was the desire of Headquarters, AAF that "overspecialization" be discontinued so that every mechanic would be able to service both Norden and Sperry equipment. This seemed a practicable because the production rate which Lowry had attained made it likely that there would be a surplus of mechanics by the end of the year.[16] Headquarters, AAF insisted that 12 weeks, or at most 20, would be sufficient for such training.[17] Another factor was the need of the Air Service Command for 1,022 bombsight repairmen, capable of performing third and fourth echelon maintenance in its depots and subdepots by the end of 1943.[18]

The new syllabus called for all students at Lowry to take a four-week "preliminary phase" dealing with electricity, tools, and the maintenance of the B-8 bombsight. Then half of the group devoted eight weeks to a Norden first and second echelon course, the other half to an eight-week Sperry first and second echelon course. At the end of these 12 weeks of training, students in both groups were screened. The half of the Norden group which had demonstrated particular aptitude was then given eight additional weeks of Norden third and fourth echelon training, becoming qualified Norden depot overhaul

men. The half of the Sperry group with unusual aptitude was given eight weeks of advanced training to qualify them as Sperry depot overhaul men. The remaining half of the Sperry group was given Norden first and second echelon training, the remaining half of the Norden group was given Sperry first and second echelon training, and thus were produced men qualified in the maintenance of both sights.[19]

Another modification to the course was the inauguration of an on-the-job training program following graduation from the course. Need for practical experience before assignment to tactical units became apparent as early as May 1941, when recruits were first admitted to the course. The situation became more acute as many organizations were shipped overseas and many additional ones activated. In June 1942 the Directorate of Bombardment made two proposals calling for Lowry graduates to serve on-the-job at bombardier schools for four weeks before proceeding to their permanent tactical units.[20] But nothing was done because it was difficult to decide who should be administratively responsible for the men during the on-the-job training period. Equally important was the feeling that the shortage of mechanics made any lengthening of the training period inadvisable.[21]

By the summer of 1943 both objections had disappeared. There was no longer an acute shortage of mechanics; the Flying Training Command and the Technical Training Command had been merged into the new Training Command. Under a directive from Headquarters, AAF, beginning early in September 1943, bombsight mechanics, upon their graduation from the Lowry course, were assigned to one of eight bombardier schools for eight weeks of practical experience. Only when this eight-week period had been satisfactorily completed

could a man be assigned to a tactical unit.[22]

During 1944 bombsight maintenance training was modified considerably to conform to new developments in equipment and methods of operation. The most profound change was brought by the recommendation of a board of officers that use of the Sperry sight and pilot be discontinued by the AAF.[23] Beginning with the class entering Lowry on 19 January 1944, all students received Norden training. Another notable development was the adoption by the AAF of the "Glide Angle Bomb," an ingenious device used in connection with the Norden sight to control the flight of the bomb after it had left the plane.[24]

To conform to these changes, the Lowry curriculum underwent constant modification during the first half of 1944. By 1 August 1944 the situation had become sufficiently stabilized to permit the announcement of the following syllabus:[25]

For All Students, First and Second Echelon

Phase 1, 2 weeks:
Manual Skills, Tools, Meters, DC Electricity, Electrical Devices; Supply Methods, Technical Orders; the Norden Stabilizer; UR Digest.

Phase 2, 6 weeks:
Bombing Problem; D-2 Sight; Norden M-Series Sight; ABC Computer; Bombsight Box, Field Repair; Bombing Trainer, Operation and Maintenance; Bomb Release Internal Controls; the Ingastat.

Phase 3, 2 weeks:
Glide Bombing Attachment, all Echelons of Maintenance and Calibration.

Phase 4, 6 weeks:
Automatic Pilot, Type C-1, Maintenance and Calibration.

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For Men Selected To Do Third and Fourth Echelon Work

Phase 5, 4 weeks:
Norden "M" Series Sight, Depot Overhaul.

Phase 6, 4 weeks:
Automatic Pilot, Type C-1, Depot Overhaul.

In September, on orders from Headquarters, AAF, all discussion of the D-8 bombsight was dropped, in recognition of the fact that this non-precision type of sight was no longer being used by the AAF. Time previously devoted to the D-8 was now given to a more extended treatment of the C-1 Auto Pilot Formation Stick.[26]

As in the case of all armament courses, those devoted to bombsight maintenance were gradually lengthened so as to include new material and to give a more thorough presentation of subject matter already offered. At the same time, the first and second echelon phase and the third and fourth echelon phase came to be considered as distinctly separate courses once again, although successful completion of the former was still considered a necessary prerequisite for admission to the latter. For convenience' sake, the first and second echelon course became known as the Bombsight Mechanic Course, while the third and fourth echelon course was called the Bombsight and Automatic Pilot Repairman Course. By V-J Day the length of the Bombsight Mechanic Course was 20 weeks:[27]

Subject	Days
Basic Electricity and M-Series Stabilizer	15
Basic Electricity	
Precision Instruments	
Classification and Custody of Military Information	
Technical Publications	
AAF Supply and Maintenance	
M-Series Stabilizer	

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Subject--Contd.	Days--Contd.
M-Series Bombsight The Bombing Problem Functions of a Bombsight M-Series Bombsight Intervalometers Microflex Timer M-Series Bombing Trainer	35
M-Series Glide Bombing Attachment (1st to 4th echelon maintenance)	10
C-1 Automatic Pilot (Calibration and Maintenance)	35
Formation Stick Control System (Calibration and Maintenance)	5

The Bombsight and Automatic Pilot Repairman Course lasted 10 weeks:[28]

Subject	Days
M-Series Bombsight and Stabilizer	25
C-1 Automatic Pilot	20
Formation Stick	5

Chapter VI

CADET ARMAMENT COURSE

The course for armament officers, given for many years at Lowry Field, was discontinued early in 1939 when the Chief of the Air Corps directed that all the personnel and facilities of the technical schools should be used to train enlisted men under the Augmentation Program.[1] This action soon produced a new problem: From where were the large numbers of armament officers to be obtained to man the greatly expanded Air Corps? The 54-Combat Group Program, adopted late in 1940, called for 392 additional armament officers. It was undesirable to reverse the order of the Chief of the Air Corps because the demand for officers was now so great that none could be spared for further training.

To the Office of the Chief of Air Corps it occurred that a likely source of officer material was the ranks of elimineos from the cadet flying schools. The notion was that these men would be given an armament course at Lowry Field; after they had successfully completed it and had spent at least nine months in the Army, they would be commissioned second lieutenants and normally would be assigned as armament officers.[2]

Asked for suggestions as to the course of training for such men, Maj. Lawrence A. Lawson of the Lowry school submitted three plans: (1) a 14-week course almost identical in scope with the

basic armament course for enlisted men for 75 per cent of the cadets; (2) a 16- to 19-week bombsight maintenance course to be given 25 per cent of the cadets earmarked for service with bombardment squadrons; and (3) a scheme calling for 25 per cent of the cadets to be selected for the 16- to 19-week bombsight maintenance course after completion of the 14-week armament course.[3]

The third of Major Lawson's plans was adopted. Beginning with a class entering on 3 March 1941 and every four weeks thereafter, 32 (33 on and after 23 June) aviation cadets began a 14-week course in armament; upon completion, eight of the cadets entered on a bombsight maintenance course lasting 16 weeks.[4] The syllabus for the cadet armament course closely resembled that in use for the enlisted men's basic armament course at the time:[5]

	Name	Hours
I.	Armament Administration Organizations and Functions of Various Types of Armament Sections. Interpretation and Use of Air Corps and Ordnance Forms, Circulars, and Technical Publications. Duties of an Armament Officer.	16
II.	Metal Work	40
III.	Soldering	8
IV.	Electrical Armament Controls	40
V.	Explosives and Ammunition	32
VI.	Chemical Warfare	24
VII.	Small Arms and Gun Cameras	40
VIII.	Aircraft Machine Guns	120
IX.	Aircraft Machine Gun Sights	40
X.	Synchronization	80
XI.	Bomb Racks, Flare Racks, and Tow Targets	80
XII.	Field Exercises	40
	TOTAL	560

No copy has been located of the syllabus for the 16-week bombsight course, to which 25 per cent of the graduates of the armament course went. It is reasonable to assume that the Lowry officials carried out their intention of using a curriculum almost identical with that employed for the enlisted men's bombsight course, with some added features from the discontinued officers' course.

A further degree of specialization was introduced a few months after the course got under way. Beginning in June 1941, the Director of Armament had the classes divided into three groups as soon as possible after they entered: (1) 35 per cent of the men were to be earmarked for service with pursuit squadrons; (2) 40 per cent with light bombardment squadrons; and (3) 25 per cent with heavy bombardment squadrons. During the latter part of the training period, especially during the field exercises phase, instruction was centered on the type of equipment with which the men would have to deal in their ultimate assignment. The addition of this feature did not affect the 16-week bombsight maintenance course which the 25 per cent earmarked for service with heavy bombardment squadrons continued to take after graduation from the armament course.[6]

The entry of the United States into the war in December 1941 had a more marked immediate effect on the pace and extent of cadet training than it did on the curricula employed. The length of the armament course was reduced from 14 weeks to 12, a new class was started every three weeks instead of four, and the size of the class

was raised from 33 to 74 men.[7] In the case of the bombsight maintenance course, the work previously given in 16 weeks was given in 12 after 5 January 1942. A new class was entered every four weeks, as previously, but the size was raised from eight to 18 men. As before, all students were men who had recently graduated from the armament course.[8]

The enormous expansion in the Army Air Forces which took place in the months immediately before and after Pearl Harbor made it necessary repeatedly to modify the prerequisites necessary for admission to cadet training. In June 1941 the War Department specified that in addition to eliminees from flying training, men might be admitted "who had successfully completed two years in college, preferably in engineering or physical science.... [provided they] are especially recommended by the CO [commanding officer] of the Air Corps school or training detachment for such training because of their evidence of outstanding mechanical aptitude as shown by their record at flying school or by previous experience."[9] This relaxation made it necessary—so the Armament Department authorities believed at the time—to endorse the records of all graduates of the course with a statement that the men could not be considered as qualified to hold a position as armament officers until they had had a certain amount of practical armament experience on the line.[10]

Another change, this one designed further to facilitate the admission of eliminees to the course, was ordered by the Chief of

the Air Corps late in November 1941. Then any eliminees qualified physically and educationally for the cadet armament course could make application directly for it. Men who had been eliminated from another cadet course for unsatisfactory progress could be admitted without prejudice.[11] By early 1942 an estimated 93 per cent of the students taking the course were eliminees from the flying schools. As Lt. Col. Charles C. Pearcy, Director of Armament asserted: "About 75% of this number bring with them a kind of 'defeatist' attitude. They lack enthusiasm and ambition, and their morale is not the best. It is evident that their chief ambition is to become commissioned officers, and not to fit themselves professionally for the serious responsibilities ahead."[12]

The close similarity between the content of the cadet course and the enlisted men's course naturally led the Lowry officials to compare the two types of students; and the comparison was not in favor of the cadets. A survey of a board of three officers appointed for the purpose declared that[13]

> there are among the enlisted men's classes an average of 7.5% students whose basic educational background is comparable to the aviation cadet average, and whose MATTC grades /while taking the armament course/ are higher than the cadet grades. This, in turn, indicates that there are among the enlisted men's classes a large number of students who possess higher qualifications than the aviation cadet average. It is assumed that the higher 11.5% of the enlisted men's classes would be later officer material, since this group is statistically higher than the aviation cadet average.

Seventeen per cent of the enlisted men made grades 2 or more per cent higher than the cadet's grades. The situation had become so

notorious locally at Lowry, according to Maj. Gen. John F. Curry, Commanding General of the Fourth District of the Technical Training Command, that it was seriously harming the morale of the students taking the enlisted course.[14]

During the spring of that year Capt. Ray V. Airmen, who presided at the survey mentioned above, has criticized the caliber of the students along the same general lines, but more pointedly. Requirements for admission to the course at that time, he observed, called for a minimum of two years in college, one year of which was to be spent in the study of physics as a major subject.[15] He continued:

> In checking through the educational records of the Aviation Cadets sent to this school, it is found that most of them have the bare two years of college and very few of them have majored in engineering. It is believed that two years majoring in sociology, psychology, history, etc., does very little to qualify Aviation Cadets towards a technical and mechanical course such as aircraft armament. A large number of the cadets entered feel that instructors at flying schools did not give them a fair break and that the Army uses them for commission as second lieutenants as a reserve for washing out of the flying school. It has been noted that morale and the esprit de corps of certain classes is very low or practically non-existent. Ease with which a commission is attained by Aviation Cadets in armament may also have a direct bearing on the number of men washed out of flying school since the rumor is prevalent at all flying schools that any wash-out is practically assured a commission merely by being entered in the armament course. Of approximately 550 cadets entered in this school, more than 200 have been eliminated, showing distinctly that these men are not making an honest effort to master the armament work, but are merely marking time waiting for the commission.

In June, General Curry proposed two measures by which the situation might be improved: (1) regulations governing aviation

cadets would be modified so that civilians and enlisted men outside the armament fields would be admitted to the course; and (2) at least one-half of the quotas for armament cadet classes should be earmarked for the top ranking fifth of each enlisted class. Men in the second category would not be obliged to take the entire cadet course, but only four weeks covering officer administrative duties not given in the enlisted course.[16]

The second request was granted by Headquarters, AAF, and beginning September 1942 a quota of 30 enlisted men out of each armament aviation cadet class of 74 was placed at the disposal of the Lowry school.[17] The change was noted enthusiastically by Colonel Pearcy, by then Director of Training at Lowry. "The most progressive step that has been taken since the organization of the Cadet Detachment . . .," he called it; "I believe the ultimate result will be superior officers . . . ."[18]

The admission of instructors and graduates of the enlisted armament and combat courses to cadet training made necessary a revision of the curricula so that this type of student would not waste time repeating as a cadet the same course of instruction he had studied as an enlisted man. During the autumn of 1942 training for cadets at Lowry was revised so that three separate courses were offered:

(1) A 14-week course known as "B," designed for men recently inducted into the Army, with little military experience, but with two years of civilian college training. A class of 12 men entered each

week. Before coming to Lowry, these men had completed nine to 12 weeks of basic military training, designed especially for cadets, at Boca Raton, Florida.[19] Their training at Lowry consisted of 10 phases, based on a seven-hour day, seven-day week schedule:[20]

	Phase	Hours
I.	Basic Armament Electricity	49
II.	Small Arms	49
III.	Explosives and Ammunition	49
IV.	Chemical Warfare Materials	98
V.	Aircraft Machine Guns and Cannon	98
VI.	Aircraft Machine Gun Sights and Gun Cameras	49
VII.	Bomb Racks	98
VIII.	Power Operated Gun Turrets	98
IX.	Administrative and Technical Duties of an Armament Officer	49
X.	Base and Field Operations	49
	TOTAL	686

(2) A six-week course, known as "AV," designed for instructors or recent graduates of Lowry and Buckley Fields. A class of six men entered each week. Before embarking upon this course, they had taken six weeks of basic military training of the cadet type, at Valley Forge Military Academy, Wayne, Pennsylvania. These men took only phases IV (Chemical Warfare Materials), VI (Aircraft Machine Gun Sights and Gun Cameras), VIII (Power Operated Gun Turrets), and X (Base and Field Operations) of the "AB" course. These four phases treated material which the students during their enlisted training had either studied not at all or in insufficient detail to perform the duties of an armament officer.[21]

(3) A six-week course, known as "BV," for men who had taken the regular Lowry enlisted men's bombsight course followed by the six-week Valley Forge course. A class of six men entered each week. The course was designed to supplement the enlisted training so as to qualify the students for service as bombsight officers:[22]

Phase	Hours
I. Calibration	49
II. Maintenance	49
III. Chemical Warfare	98
IV. Small Arms, Machine Guns, and bomb Racks	49
V. Base and Field Operations	49
TOTAL	294

In January 1943 the three courses were moved from Lowry to a new technical school at Yale University, where all AAF ground duty cadet training was being centered. The extra facilities available there made it possible, two months later, to increase the quotas of each of the classes by more than 100 per cent--the "AE" course to 25 new men per week, the "AV" course to 12 per week and the "BV" course to 12 per week.[23]

During the spring of 1943 Headquarters, AAF concluded that, in order to facilitate the assignment of officers and to conform to recent tables of organization, the category of "bombsight maintenance officer" should be eliminated. Thereafter, armament officers were to be charged with responsibility for the maintenance not only of general armament, but of bombsights and power operated turrets as well.[24] Accordingly, on 31 May Headquarters, AAF ordered the Technical

Training Command to discontinue the separate bombsight course and to lengthen the armament course to include phases on bombsight maintenance, making the transition as quickly as possible but gradually enough to produce an even flow of graduates.[25]

The Yale school authorities took the opportunity to propose a thorough revision in the cadet program. Instead of three separate courses, only one would be given. The "AV" course was to be discontinued entirely; and the chief features of the "AB" and "BA" courses were to be combined into one 20-week course, three weeks of which were to be devoted to Chemical Warfare. Headquarters, AAF cut the time devoted to this topic to one week, however, making the course only 18 weeks in length.[26]

Training under this new curriculum began on 1 July 1943. Subsequent minor modifications produced the following syllabus, which was placed in effect on 13 October 1943:[27]

	Phase	Hours
I.	Armament Administration	36
II.	Machine Guns and Small Arms	36
III.	Aircraft Cannon	36
IV.	Engineering Physics	36
V.	Bombs, Fuses, Ammunition and Racks	36
VI.	Synchronizing, Aircraft Machine Gun Sights and Gun Cameras	36
VII.	Power Operated Gun Turrets	144
VIII.	Bombsight Maintenance	180
IX.	Chemical Warfare	72
X.	Armament Field Operations	72
	TOTAL	684

Two phases are worthy of comment because they represent the first of considerable experimentation and modification by the Yale school authorities. The four-week phase on power operated gun turrets included two weeks of the material which had been taught for some time plus two weeks on the central fire system.[28]

Five weeks were devoted to bombsight maintenance. The first week dealt with the "theory of bombing"; the second week with the Norden bombsight M-6; the third week with the Sperry S-1 bombsight; the fourth week with the Honeywell C-1 automatic pilot; and the fifth week with the Sperry A-5 automatic pilot.[29]

Two technical developments in the field of bombsights led to further modifications in the cadet course during the first half of 1944. Some months after Headquarters, AAF decided that the Sperry bombsight and A-5 automatic pilot equipment was to be discontinued by AAF units, it directed the Training Command to give only "familiarization" training to this type of equipment and use the time thus saved to add instruction on the Norden M-9 bombsight and the C-3 automatic pilot.[30] As the Yale school worked it out, starting early in February, two days were devoted to the Sperry equipment. The 10 days saved by the reduction permitted two extra weeks on Norden equipment, greatly increasing the thoroughness of that training.[31]

At about the same time the AAF adopted the use of the "glide bomb," a device used in connection with the Norden sight to control the flight of the bomb after it had left the plane. A sixth week was added to the bombsight maintenance phase to cover familiarization training on

this equipment, raising the over-all length of the cadet course to 19 weeks.[32]

By the spring of 1944 Headquarters, AAF became convinced that with the peak of AAF expansion already reached, it was inadvisable to continue commissioning men on any large scale. Future needs for technical officers, it was felt, could best be met by giving technical training to men already commissioned for whom no suitable assignment existed in their previous specialty.[33] Ultimately it was determined that the men selected for this re-training should be rated pilot officers returned from overseas duty. This decision produced a new problem: To maintain at least minimum flying efficiency, these pilot students would require far better facilities than were available at Yale, where the air base was several miles away from the main part of the school. The solution reached was that technical training should be moved to regular AAF fields; the armament course was to be moved to Buckley Field, Colorado.[34]

The transfer of the armament department was made phase-by-phase during the summer of 1944. As the instructors of each phase finished teaching their last class at Yale, they and their equipment moved to Buckley and resumed instruction there. Thus it was possible for the first class of 14 officer pilots to start the course at Buckley on 24 July, while the last class of cadets did not graduate from Yale until 15 November.[35]

With the change in purpose of the course and in type of student, came modifications in the curriculum and teaching methods. At Yale

some enlisted personnel had been used to teach the cadets; at Buckley, as the students were officers, the instructors all had to be officers. Although the content of the course remained basically the same, the order and manner of presentation was drastically reorganized. Over a 19-week period, the following topics were presented:[36]

I. Theory of Bombing
- (a) Handling of Classified Material
- (b) Handling of Bombsight Equipment
- (c) Trigonometry of the Bombing Problem; Square Root and Trigonometry of Right Angles
- (d) Indicated, Calibrated Indicated, and True Air Speed
- (e) Ground Speed and Velocity of Closing
- (f) Physics: Increasing Speed of Falling Objects
- (g) Physics: The Vacuum Bomb
- (h) Actual Bomb: Actual and Whole Range
- (i) Actual Bomb Trail
- (j) Actual Bomb Crosstrail
- (k) Bomb Ballistic Charts: Use of Charts
- (l) Gyroscopes: Characteristics and Laws
- (m) Gyroscopes: Use of Gyros in Precision Bombing Equipment
- (n) Precision Bombing Equipment: Solution of Trail, Crosstrail, and Range on L-9 Bombsight
- (o) Precision Bombing Equipment: Manual Computers: E-6-B, ABC

II. Machine Guns and Small Arms
- (a) Pistol Caliber .45, Carbine Caliber .30, Submachine Gun M-3
- (b) Small Arms Ammunition; Storage, Handling & Target
- (c) Browning M.G: Assembly, Disassembly, Nomenclature
- (d) Headspace and Headspace Adjustment
- (e) Operation of Feeding Mechanism
- (f) Operation of Firing Mechanism
- (g) Inspection, Maintenance, Cleaning and Lubrication
- (h) Requisition of Spare Parts

At Buckley instruction was carried on in a large hangar which had been partitioned into classrooms. Proximity of the classrooms to the flying line made it possible to give practical demonstrations of

the material covered during each phase instead of reserving it for a "field exercise" period at the end of the course.[37] When the school at Buckley was activated, plans called for the training of 39 classes there, with the last class graduating on 8 December 1945.[38]

Chapter VII

INSTRUCTIONAL AND ADMINISTRATIVE PROBLEMS

The foregoing chapters have described in some detail the vicissitudes of the principal courses in aircraft armament. In theory, the function of Headquarters, AAF, the Training Command, and the Western Technical Training Command was to establish the over-all requirements and standards of armament training; upon the school authorities at Lowry, Buckley, and Yale rested the responsibility of determining the detailed methods by which these objectives were to be achieved.[1]

As the chapters on the particular courses have shown, these principles were not always strictly adhered to. Although in almost every instance the syllabus was drawn up by the school giving the course, in many cases subsequent modifications ordered by higher headquarters altered it tremendously. This was particularly true when higher headquarters would order the addition of considerable bodies of new subject matter to the curriculum but would deny the school any extension in the over-all length of the course.

Oftentimes school authorities complained that this occurred because the officers at the higher headquarters were unfamiliar with the problems of their school. They made such complaints in spite of the fact that, during the war years at least, every one of the co . and headquarters had on its staff at least one former official of an

armament school whose responsibility was the monitoring of the armament training program. What the school authorities forgot, when they complained, was that the decisions of higher headquarters were in most cases guided by factors of which they had no knowledge. At the same time there was considerable merit to the school authorities' contention that after a tour of duty of a year or more on a headquarters staff, the most experienced former armament school official lost touch with the changing conditions at the schools, and that much might be gained by a more frequent rotation of headquarters personnel.

The personnel of both school and headquarters seem to have agreed that the armament courses might have been conducted on a more realistic and efficient level if the training officers had been permitted to make rather frequent trips to operational units in combat areas. In one or two instances such trips were made, but they were the exception rather than the usual practice. Intelligence reports and written suggestions submitted through channels by the using organization required a long time to reach the armament schools; by the time they did reach their destination, conditions usually had altered or the suggestions had been so watered down by the numerous forwarding organizations as to make them of relatively little value. During the last months of the war, as part of the AAF's personnel rotation policy, men who had had combat experience began to reach the armament schools as students and instructors; but the narrowness of the experience of most of them and the constantly changing conditions of warfare

limited the value of this practice.

Although the armament school officials were responsible for drawing up the syllabus which they provided their students and instructors, they deliberately refrained from making them very detailed. They did this for three reasons: to permit the instructors to exhibit individual initiative in their teaching; to allow constant modification of the course in the light of new equipment and techniques; and to avoid the numerous "gigs" they felt inspectors would be certain to submit if they observed any deviation from the announced standards. But the school authorities did succeed in maintaining definite standards of instruction by giving students examinations at the end of each phase and at the end of the course.

There was one particularly notable instance of a higher headquarters undertaking to establish detailed teaching procedures without the concurrence of the armament schools. At the start of the Air Corps expansion period, armament training tended to be theoretical. Much of the instruction was presented to large class sections through the traditional lecture and blackboard method. Supplementary aids included Air Corps technical manuals and a few training films, none of which had been prepared specifically for the purpose of the course. Such methods caused the armament officer of the Third Wing, GHQ Air Force to complain in the spring of 1940 that graduates of the Lowry bombsight course assigned to his wing appeared to know far more about what happened to a bomb after it was dropped and the relative merits of the Norden and Sperry sights than they did about the actual maintenance of the equipment.[2] But armament instruction was not all

theoretical. In most phases there was an adequate amount of equipment for teaching purposes; and since the courses were given at a leisurely pace, students had fair opportunity actually to practice maintenance work in the classroom.

During 1941 and 1942, when equipment training was expanding by leaps and bounds, the trend toward the theoretical grew stronger and stronger. With larger classes, inadequate numbers of experienced instructors, and greatly shortened courses, such a development was almost inevitable. In some phases the officials undertook to counteract this by preparing additional schematic charts, printed or mimeographed student manuals and guides, and similar pedagogical devices. Short answer true-and-false examinations were substituted for essay-type examinations. But at best the efforts to prevent excessive theory were only partially successful.

During the autumn of 1942 Maj. Gen. Walter R. Weaver, Commanding General of the Technical Training Command took drastic step to shove the pendulum back in the direction of the 'practical.'[3] He ordered an increase in the ratio of instructors to students so that there would never be more than eight students in a class group. His directive further forbade the use of lectures, the keeping of notebooks by students, and the testing of students by written or oral examinations. It ordered the removal of all chairs and blackboards from classrooms. Use of modern training aids was to be increased.

Under the impetus of the directive, more charts and student guides were prepared for all phases.[4] More training films and film

strips illustrating such things as proper methods of disassembly, assembly, and cleaning were obtained from the motion picture services. Additional cutaway models of machine guns and cannon were obtained from the manufacturers to demonstrate how the equipment operated. "Headboards" and "mock-ups" were constructed by members of the school staff to illustrate such things as the malfunctions common to the electrical system controlling armament and the internal construction of bomb fuzes. Exhibits of dummy ammunition and bombs were prepared so that students become familiar with their appearance. More "machine gun malfunction" laboratories were built, where students could learn to recognize the symptoms of the most common type of malfunctions. Additional chutes were constructed so that students might practice the synchronization of guns. Additional cutaway airplanes were procured from the material authorities and installed in the school hangars so that students might practice such routine duties of the armorer as the loading of machine gun ammunition and the fuzing and loading of bombs. This practice was followed even in the cadet courses at Yale, in spite of the inconveniences created by ivy-covered buildings and an airport seven miles from the classrooms.

Many of the armament school officials believed that although the purpose behind the directive abolishing theoretical instruction was worth while, its provisions went too far and were better suited for aircraft-maintenance training than for armament. In such phases as explosives and ammunition, and electrical Armament Control, where the

nature of the subject matter made advisable the use of the lecture method, supplemented by occasional demonstrations through charts and breadboards, the ban on lectures and chairs was winked at. In phases dealing with bombing guns and cannon, groups of eight students and an instructor bravely stood around a cannon or gun for the six hours of a school day.

The discontinuance of examinations added considerably to the problems of the instructors in grading the students. But by 1943 the elimination rate allowed most armament courses was so tiny that students had to be graduated whether their work actually met any standard or not. The directive had one positive benefit: the ban on blackboards and student notebooks hastened the preparation of additional charts and breadboards to take their place.

Some time after the absorption of the Technical Training Command by the Training Command in July 1943, permission was granted the armament school officials to deviate from some of the provisions of the directive instituting practical methods, at first unofficially, and later officially. Written examinations of the objective type were reinstated; a moderate amount of lecturing to small groups was condoned; and chairs were returned to the classrooms for many of the phases. But the pedagogical efficacy of breadboards, mock-ups, and charts having been demonstrated, there was no abatement in their use. As the supply situation gradually eased, cutaway as well as regular models of equipment became more generally available, further improving the effectiveness of the courses.

In its effort to stress the "practical," the armament school at Lowry conducted an interesting experiment during the first half of 1943. An area known as Camp Bizerte, simulating conditions characteristic of an advanced tactical base, was opened on the Colorado plains some miles east of Lowry. Following the completion of the phases at Lowry, students spent a week at Camp Bizerte living in tents, eating and working in the open, and practicing under "rugged" conditions the things they had learned in the classroom. Reports received from the North African theater were used to teach methods of armament maintenance under desert conditions. The camp was abandoned after about six months, when the production "hump" of armorers had been surmounted. Undoubtedly the students who took this training benefited from the lessons in improvisation which it taught. It is doubtful, however, whether the information they acquired about African conditions was of particular benefit; by the time these students were sent overseas, the USAAF was fighting from Italy and northwestern Europe.[6]

By the end of the war the armament school officials were inclined to believe that they had achieved a happy solution to the "theoretical versus practical" instruction problem. Much of this was made possible by the improvement in the supply and personnel situations. In most instances each student could be provided with his own piece of equipment. There were enough instructors now for at least one instructor for every five students in the depot overhaul courses, and one instructor for every eight students in every first and second echelon course. Normally an

instructor gave a brief explanation of the theory which lay behind an operation, and followed it with a series of demonstrations and exercises which were participated in by all the students. The ratio between "practical" and "theoretical" instruction was then estimated at 80 to 20, with "practical" instruction running considerably higher during the phases on the bombsight, the C-1 pilot, and the E-29 computer. Precautions were taken to guard against the natural tendency of instructors to become extremely voluble.

One administrative problem which vexed armament training officials more than it did those in charge of other technical courses was that of student-and-instructor morale. That this was so is illustrated by the elimination rate which obtained at Lowry Field, the only school then giving the course, during the school year 1941-42. The elimination rate for students entering the basic armament course was 22.33 per cent; for those entering the bombsight maintenance course, 12.81 per cent; and for those entering the power operated gun turret course, 6.32 per cent. The rates of the first two courses were considered undesirably high; the goal for technical training was to keep eliminations well below 10 per cent. Particularly unsound was the rate in the basic armament course; this was not a particularly difficult subject and could easily be mastered by an eighth-grade graduate.[7]

Morale was such a trying problem because aircraft armament was a strictly military specialty. When a man studied aircraft maintenance or communications or photography in an AAF technical school, he did it with the realization that the knowledge he was acquiring would have some utilitarian value in the civilian world to which he would ultimately

return. He could not comfort himself with any such thought in the case of aircraft armament. As some students sarcastically expressed it: "After the war I'll get a job taking care of Al Capone's machine guns."

Moreover, armament lacked the glamour of the combat crew specialties. The pilot, the bombardier, the navigator, even the flexible gunner, were romantic heroes of the movies, the radio, and the comic strips. But about the greatest degree of immortality the ground armorer ever achieved was an enthusiastic tribute from the late Ernie Pyle published in his syndicated column early in 1944.[3] The situation was well summed up by Col. William L. Travis of AC/AS, Training, formerly of the Armament Department, when he wrote in November 1943:[9]

> The lowly status in which armament has fallen is due to the tremendous amount of publicity given gunnery, bombing, etc., and an impression that a knowledge of armament is unnecessary to such popular jobs. The armament Schools have requested just one film to show to entrant students for the specific purpose of inciting interest. Two scenarios have been turned in and turned down in the past three years, and the Schools referred to similar films on gunnery. Many of our armorers will never become gunners, and the use of such film was looked as a substitute would decrease the morale which is already low. The armament section of the new Pilot's Information File is typical of the general view toward armament, six little pages including a chart. There is a definite need for an educational program on armament for all unit armorers, pilots, and station technical inspectors.

There is no record that any action was taken on Colonel Travis' suggestion.

One time when the AAF did let have accomplished a good record "selling" armament work to the men destined to be trained in that specialty

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...ng during the classification period of basic military training. But questioning by school officials of recruits sent to them disclosed the fact that the classification interviewers at some basic training centers not only were ignorant about the nature of armament work, but were actually presenting misinformation. Some interviewers appeared to believe that armament work was sheet metal work. Others told recruits that the course led to or covered aerial gunnery--which led to badly shaken spirits when the men arrived at school to learn that only a few would ever operate a machine gun or cannon. Even when interviewers were better informed, the ever-present "latrine rumors" accomplished the same mischief.

Another factor which led to such dissatisfaction was the quota system under which the Army classification system operated. At classification centers recruits were allowed to state three choices as to courses. Many men picked airplane mechanics or radio as their first or second choice, listing armament as third choice only because there was no other likely possibility. They were bitter when they learned that, in order to fill a large class at Lowry or Buckley, their reluctant third choice had been made their assignment.

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The failure of headquarters, AAF and the classification centers to improve the morale situation placed the problem almost entirely upon the shoulders of the armament schools. In the power operated gun turret course, considerable time was devoted to explanations of the importance of turrets in bombardment warfare. In the even more critical case of the basic armament course, a day or two before matriculating

students were given an orientation lecture during which an effort was made "to impress upon the student the importance of the armorer's job in a tactical organization." Throughout the course, too, instructors were expected to reiterate this point to the students. But as the school authorities grimly observed, most of their efforts went for naught when students received letters from friends who had been graduated from the course and had been assigned to miscellaneous post and squadron duties at their next station.[11]

The armament schools adopted a number of improvisations to control student morale. During the period in which the schools were expanding, there was a great need for enlisted personnel to perform clerical and other administrative chores around the post—the so-called "permanent party" assignments. This need led post officers to detail eliminees from the schools to such duties. As the practice became common, many students, none too eager for assignments as armorers and attracted by the Colorado climate, deliberately sought to be eliminated so that they might become permanent party members. When it was realized that this was pulling down the morale of the student body as a whole, an order was issued that henceforth no eliminees were to be retained at the schools for such assignments. But by this time most of the mischief had been done, and all of the permanent party assignments were filled.

A fresh incentive to basic armament students to get themselves eliminated from the course was provided by a directive of the Training Command issued in December 1943 which required that all enlisted men hereafter dropped from a basic course and qualified for combat crew training, were to be [redacted] gunnery schools at once. As soon

as they learned this, students desiring aerial gunnery training began deliberately to fail their work, sometimes even remaining absent from class. Where it was clear that failure was deliberate, the authorities entered the fact that the student had been dropped "with prejudice" on his service record.

The situation grew so distressing that the Lowry officials proposed to higher headquarters that deliberate failures be transferred immediately to the Ground Forces, or at least be permanently deprived of the privilege of taking flexible gunnery training. But the Training Command refused to authorize either proposal on the grounds that no means then existed for transferring men to the Ground Forces and that the need for flexible gunners was so acute that they must be given high priority.[12]

In the circumstances, the best the school was able to do was establish an elaborate system of boards of officers to interview men whose work was not satisfactory. If there was any reason to suspect that the cause of a man's failing work was his desire to obtain another assignment, he was to be disciplined under the 104th Article of War, or threatened with it.[13] But the Lowry authorities doubted whether these measures did any more than mitigate the situation. In the spring of 1944 the elimination rate of the basic course dropped to the vicinity of 1%. The students during this period, however, were mostly eliminated flying cadets earmarked for aerial gunnery training, whose morale, though low upon arrival at the school, improved rapidly "through orientation and judicious handling."[14]

Another type of student-morale problem developed during the spring of 1943, when a number of enlisted men who had already been graduated

from aerial gunnery school were sent to Buckley and Lowry to take the basic armament course. At gunnery school, according to the armament course authorities, these men had been imbued with the belief that they were the most important cog in the AAF, and that their gunnery training had taught them all they needed to know about armament. Many of them already held higher rank than the armament instructors, which created problems of discipline. The situation was ultimately improved by the adoption of a policy that all men picked as armament-gunners were to receive their armament training before going to gunnery school.[15]

In the case of the central fire control course, a very difficult one which could be mastered only by men with unusual qualifications, student morale was generally referred to as "very high." One reason for this was that, with occasional exceptions, only men with AGCT scores of 110 and over—well above the Army average—and considerable mechanical experience were admitted. But an authorization to promote all graduates of the course to the rank of corporal, unless they already held that rank or a higher one, unquestionably did a good deal to improve the spirit of the students.[16]

One of the wisest measures adopted to raise student morale was that of selecting outstanding students in each class to take the cadet armament course leading to a commission and assignment as an armament officer.[17] Although exact figures are not available, there is evidence to suggest that proportionately more armament instructors than students were given the opportunity of taking cadet training. For this reason,

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the cadet program probably boosted the morale of the instructors even more than that of the students.

Because they dealt with classified subjects, the bombsight maintenance, power operated turret, and central fire control system courses all involved an administrative problem found in few other types of technical training: security. The problem first appeared and was most acute in the case of bombsight maintenance, a subject classified as "confidential." In 1939 the Chief of the Air Corps established a rule that the loyalty of every prospective student must be checked; he must "be a citizen of the United States of unquestioned loyalty, trustworthiness and reliability" who has served in the Army for at least three years. The statement of the commanding officer of the post at which the soldier was stationed had to be sufficient proof.

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The revelation in July 1941 that a cadet bombsight instructor had a felonious record so disturbed the Air Corps Legal Division that it advocated immediate stiffening of the requirements. The Chief of the Air Corps responded with a new regulation specifying that no person would be trained as a bombardier or bombsight maintenance man until his application, together with a set of his fingerprints, had been submitted to G.H.Q. and approved. Before granting this approval, the Chief of the Air Corps had Military Intelligence check the candidate's record and fingerprints with the Federal Bureau of Investigation.

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In practice, this investigation of loyalty qualifications took a long time—so long that it became customary to wink at the letter of

the regulation are allowed students to start the course while their records were still under investigation. It was a common occurrence at the Lowry school for men to be permitted to reach the last two weeks of the course before being cleared. In one instance a student was removed when an unfavorable report was received the day before he was to graduate.[20]

Col. L. S. Smith, Director of Individual Training, made a radical suggestion in March 1942. Because of American losses of heavy bombers, he believed it reasonable to assume that some bombsights had fallen into enemy hands. Thus, he thought, there was no longer any need for investigating the loyalty of men who maintained and operated bombsights any more than those who maintained and operated the planes.[21]

AAF authorities were not yet ready to accept a suggestion as novel as Colonel Smith's. The revision of AAF Regulation No. 35-13 issued in April 1942 continued to require that an investigation be made into a prospective student's loyalty, but prescribed a procedure designed to expedite the investigation. A few more months of experimentation with this regulation, however, convinced the War Department of the validity of the point of view expressed by Colonel Smith. In November 1942 the Secretary of War directed the commanding generals of the various air forces and commands to cease forwarding prospective students' fingerprints to Headquarters, AAF.[22] Early in 1943 the classification of bombsights and literature relating to them was lowered to "restricted" and the investigation dropped entirely.[23]

RESTRICTED
SECURITY INFORMATION

Despite the lowering in classification, for some time afterward the officials at Lowry continued to treat bombsight materials and information as confidential matter. As before, at the start of the course, AF 380-5, dealing with the handling of classified matter, and Lowry Field rules in respect to combat bts were read to the students, who were then required to sign a certificate indicating their willingness to abide by these security regulations. The students were given passes admitting them to the bombsight division buildings, which were separated from the rest of the field by a fence. They were warned not to discuss the subject matter of the course with any outsider, military or civilian. Only on rare occasions were students permitted to remove textbooks and class notes from the classroom area, although this rule was later liberalized to permit their use in the barracks. With the inauguration in 1943 of the central fire control course, which dealt with secret material, the Lowry school followed in general the same practices then in effect in the bombsight maintenance course.[24]

G L O S S A R Y

AAF	Army Air Forces
AAG	Air Adjutant General
AC/AS	Assistant Chief of Air Staff
AC/S	Assistant Chief of Staff
ACTS	Air Corps Technical School
ACTTC	Air Corps Technical Training Command
AFASC	Air Service Command
A.F.C.E.	automatic flight control equipment
AFCTG	AC/AS-3, Training Division, Technical and Services Training Section
AFPMP	Directorate of Military Personnel
AFRDB	Directorate of Bombardment
AFRIT	Directorate of Individual Training
AFSHO	AAF Historical Office
AFTRC	Air Forces Training Command
AFTTC	Air Forces Technical Training Command
AG	Adjutant General
AGCT	Army General Classification Test
ASC	Air Service Command
C/AAF	Chief, Army Air Forces
C/AC	Chief of the Air Corps
CFCE	central fire control equipment
CG	Commanding General
CO	Commanding Officer
ETTC	Eastern Technical Training Command
Comdt.	Commandant
G-2	General Staff, Intelligence
GHQ AF	General Headquarters Air Force
ind.	indorsement
M&D	Materiel, Maintenance, and Distribution
n.d.	no date
OASW	Office of the Assistant Secretary of War
OCAC	Office of Chief of the Air Corps
OC&R	Operations, Commitments, and Requirements
POGT	power operated gun turret
R&R	routing and record sheet
RCT	remote control turret
SSN	specialist serial number
TAG	The Adjutant General
TC Memo	Training Command Memorandum
TS	technical school
TTC	Technical Training Command
TWX	telegram
T&O	Training and Operations
UR	unsatisfactory report
USAAF	United States Army Air Forces
WTTC	Western Technical Training Command

NOTES

Chapter I

1. Memo on Mechanics training during World War I, unsigned and undated, in AG 353.9 Mechanics Tng.

2. Memo, "The Air Corps Technical School," unsigned and undated, in History of Army Air Corps Technical Training, 1917-41, doc. 1f.

3. History of Chanute Field, 1 Jan. 1939-7 Dec. 1941, vol. 1, p. 13.

4. Memo, "The Air Corps Technical School," unsigned and undated, in History of Army Air Corps Technical Training, 1917-41, doc. 1i.

5. History of Lowry Field, Armament Department, vol. 2, ch. 2, pp. 31-32.

6. Memo, "The Air Corps Technical School," and "History of the Department of Armament, ACTS," in History of Army Air Corps Technical Training, 1917-41, docs. 1f, 1h.

7. "History of the Department of Armament, ACTS," in Ibid., doc. 1h.

8. Annual Report, School Year 1935-36, Department of Armament, Lowry Field, and grade cards for Class 2-1-36, quoted in [Chanute] Field, and History of Lowry Field Armament Department, vol. 2, ch. 2, pp. 10-11.

9. Ibid., pp. 1, 2, 4, 5.

10. Ibid., pp. 13-16.

11. "History of the Department of Armament, ACTS" and Memo for Dir. ACTS by C.J. Coors, Chief Instructor, 14 March 1935, in History of Army Air Corps Technical Training, 1917-41, docs. 1h, 1e.

12. "History of the Department of Armament, ACTS," in Ibid., doc. 1h.

13. Class records quoted in History of Lowry Field Armament Department, vol. 2, ch. 2, pp. 13-39.

14. Ibid., pp. 2, 3.

15. Ibid., pp. 90-93.

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Chapter II

1. Memo, School Secretary, ACTS, Lowry Field to Dir. of Armament Dept., 28 April 1939, cited in History of Lowry Field Armament Dept., vol. 2, ch. 2, p. 253; memo, C/S to Lt. Col. Russell L. Maxwell, C/S., 20 Jan. 1939, in AG 353.9A, Tng., Gen.

2. Ltr., Lt. Col. Ira C. Baker, Exec., C/C to CG, 21 June 1939, in AC 352.11 f Chanute Fld. Course of Instruction; 1st ind., C/AC to CG, 25 Jan. 1939, in AG 353.9A, Tng., Gen.

3. C/AC to AC/S, G-2, 29 Dec. 1942, in AG 353.9-1A, Bombsight Tng.

4. Inspection Report on Scott, Lowry, and Chanute Flds., "in accordance with par. 1, Office Memo 30-11, 23 August 1938," signed by G.E. S/tratemeyer/, Chief, T&O Div., dated 1 Nov. 1939, in AFCTC files.

5. OCAC, /monthly reports of Stat. Control Sec.

6. Ltr., C/AC to Exec., Chanute Fld., 21 Sep. 1940, quoted in History of Lowry Field Armament Department, vol. 2, ch. 2, pp. 253-254.

7. Director of Armament Dept., Lowry Fld. to Brig. Gen. Rush B. Lincoln, 15 Nov. 1940, quoted in ibid., p. 264.

8. Memo, Asst. Dir. of Armament Dept., to Exec., ACTS, 12 Nov. 1940, quoted in ibid., p. 261.

9. Radiogram, CG/C to Lowry Fld., 24 March 1941, quoted in ibid., p. 264.

10. OCAC, monthly reports of Stat. Control Sec.

11. 2d ind., C/AC to CG, ACTTC, 15 Sep. 1941; and 5th ind., C/AC to CG, ACTTC, 27 Oct. 1941, in AG 220.66 A1, Detail of Students to Factory Tng., Misc.

12. Asst. Comdt., Lowry Fld., to Lt. Col. Brock, 20 Nov. 1940, in AG 353.9A, Denver Misc. Tng; History of Lowry Field Armament Department, vol. 2, ch. 2, pp. 95-96.

13. Memo, Brig. Gen. Davenport Johnson to C/AC, 10 March 1941, in History of Air Corps Technical Training, 1917-41, doc. 80; History of Lowry Field Armament Department, vol. 2, ch. 2, pp. 264-265.

14. Comdt., ACTS, Lowry Fld. to C/AC, 13 Sep. 1940, quoted in History of Lowry Field Armament Department, vol. 2, ch. 2, p. 154; Capt. W.F. Day, Supervisor Power Turret Phase, Armament Sch. to Dir. of Armament Post, Lowry Fld., 15 Nov. 1941, quoted in ibid., p. 166; Comdt., Lowry Fld. to CG, ACTTC, 13 Oct. 1941, quoted in ibid., p. 167.

15. Memo, for Brig. Gen. Cousins, Report Code No. 1, approximately 1 Jan. 1942, in Administrative Management Div. Files, Bureau of the Budget.

16. Radiogram, Mazon, ACTTC to CG, ACTS, Lowry Fld., 6 Dec. 1941, and Daily Diary of Lowry Fld. Armament Dept. Dec. 1941, cited in History of Lowry Field, 7 Dec. 1941-31 Dec. 1942, vol. 2, ch. 6, p. 57; school regulation, Lowry Fld. Dept. of Armament, 1 Jan. 1942, quoted in ibid., p. 26.

17. Capt. Roy Collins, Actg. AG, 4th Dist., AFTTC to CO, Lowry Fla., 13 Oct. 1942, quoted in ibid., p. 397.

18. CG, Buckley Fld., quoted in History of Buckley Field Armament School, 7 June-31 Dec. 1942, ch. 6, p. 11.

19. Memo of telephone conversation, W. Mitchel and D.H. Baldwin, 18 April 1942, prepared by W. Mitchel for J.S. Canterbury, 20 April 1942, in Administrative Management Div. files, Bureau of the Budget; Hq. AAF, PAR, AFRDB to AFMIT, 8 June 1942, in AAG 353.9-LA, Bombsight Tng.

20. CG, ACTTC to CMC, 17 Sep. 1941, in AAG 353.9-LA, Bombsight Tng.

21. Annual Report of Lowry Fld. Armament Dept., 30 June 1942, quoted in History of Lowry Fla.,1942, vol. 2, ch. 6, p. 14.

22. History of Buckley Field, April-Dec. 1942, p. 13.

23. Lt. Col. William F. Day, Dir., Armament Dept., to Supervising Officer, 59th Subdepot, Lowry Fld., 24 Dec. 1942, quoted in History of Lowry Field, 1942, vol. 2, ch. 6, p. 150.

24. Capt. Roy Collins, Actg. AG, 4th Dist., AFTTC to CO, Lowry Fld., 14 Sep. 1942, quoted in ibid., p. 99.

25. History of Armament Training School, 7 Dec. 1941-31 Dec. 1942, pp. 6-31.

26. See p. 54 ff., this study.

27. Hq. AAF, monthly reports of Stat. Control Sec.

28. Col. L.O. Ryan, Deputy AC/AS, Tng. to AC/AS, OC&R, 10 Feb. 1945, in AFCTG files.

29. Hq. AAF, monthly reports of Stat. Control Sec.

30. TWX, ETTC to CO, TS, Yale University, 10 June 1944, reproduced in History of TS, Yale University, 1 May-30 June 1944, incl. 11.

31. Hq. AAF, monthly reports of Stat. Control Sec.

32. Ibid.

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Chapter III

1. Lt. Col. Ira C. Baker to TAG, 21 June 1939, in AAG 352.11F, Chanute Fld. Course of Instruction; schedule for school year 1939-40, reproduced in History of Lowry Field Armament Department, vol. 2, ch. 2, pp. 69-74.
2. Exec., Lowry Fld. to Dir. of Armament, 19 Aug. 1940, quoted in ibid., p. 21.
3. Schedule for school year 1940-41, reproduced in ibid., pp. 76-77.
4. Schedule for school year 1941-42, reproduced in ibid., pp. 78-79.
5. Daily Diary of Lowry Fld. Armament Dept., Dec. 1941, cited in History of Lowry Field, 1942, vol. 2, ch. 6, p. 57.
6. Capt. Roy Collins, Actg. AC, 4th Dist., AFTTC to CO, Lowry Fld., 14 Sep. 1942, cited in ibid., p. 99.
7. 1st ind., Col. Harvey S. Burwell, TS, Lowry Fld., to CG, AFTTC, 16 Sep. 1942, quoted in ibid., pp. 99-111; syllabus of instruction, Fighter Aircraft Armorer's Course, TS, Buckley Fld., 20 Oct. 1942, reproduced in History of Buckley Field Armament School, 7 June-31 Dec. 1942, n.p.
8. Capt. D.T. Hamilton, Asst. AC, AFTTC to CG, 4th Dist., AFTTC, 24 April 1943, cited in History of Lowry Field, 1 Jan-7 July 1943, vol. 2, ch. 11, p. 79.
9. Capt. K. S. Brown, Actg. Asst. AC, 4th Dist., AFTTC to CO, TS, Lowry Fld., 29 April 1943, quoted in ibid., p. 80.
10. Col. Edw. D. Bewley, Comdg., TS, Lowry Fld. to CG, 4th Dist., AFTTC, 29 April 1943, quoted in ibid., p. 81.
11. Brig. Gen. Albert L. Sneed, Comdg., TS, Lowry Fld. to CG, 4th Dist., AFTTC, 6 May 1943, quoted in ibid., pp. 82-84.
12. Brig. Gen. A.L. Harper, AC/AS, Trng. to CG, AFTAC, 17 July 1943, cited in History of Lowry Field, 8 July-31 Dec. 1943, vol. 2, ch. 16, pp. 7, 8.

13. Brig. Gen. A.L. Sneed, Comdg., TS, Lowry Fld. to CG, 4th Dist. AFTTC, 8 Aug. 1943, quoted in ibid., pp. 8-9.

14. Capt. R.L. Holcomb, Actg. Asst. IG, AFTTC to CG, AFTTC, 28 Aug. 1943, cited in ibid., p. 10.

15. Program of instruction, 18 Oct. 1943, reproduced in ibid., pp. 13-14.

16. 2d ind., Capt. A. T. Adam, School Secretary, Lowry Fld. to CG, AFTTC, 17 Sep. 1943, cited in ibid., pp. 11-12.

17. Ltr., Col. S. Montgomery, Air Chemical Officer, AAFTD to AC/AS, Trng. (Tech. Trng.), 8 June 1943, in AAF 353 Armament Trng.

18. Fixed forward-firing 75-mm. cannon (Type T-4) had first been installed on B-25's in April 1943, and a demand immediately appeared for armorers qualified to maintain them. At the outset it was felt that this large-size cannon would not be used widely enough to warrant including it in the basic armament course. Accordingly, in March Lowry started offering a special six-day course for an average of 35 armorers on detached service from units which used this cannon. Subsequently a few unassigned graduate armorers were also detailed to the class. (History of Lowry Field, 1 Jan.-7 July 1943, vol. 2, ch. 11, pp. 119-127.) Several months of experiment convinced the Lowry authorities that the cannon could be taught adequately in three school days. During that time the weapon was adopted more widely than had been expected, and so a three-day phase was incorporated into the 12-week basic armament course. History of Lowry Field, 8 July-31 Dec. 1943, vol. 2, ch. 16, pp. 27-28.

19. Ibid., p. 28. First and second echelon maintenance of these turrets was being taught in the nine-week power turret course.

20. 1st ind., Capt. A.S. Brown, Actg. AG, AFTTC to CG, AFTTC, 28 Oct. 1943, cited in ibid., pp. 70, 71.

21. Capt. Robert S. Hirson, Dir. of Armament, TS, Lowry Fld. to Dir. of Trng., AFTTC, 29 Oct. 1943, quoted in ibid., pp. 74-75.

22. AAF Training Standard 2C-51, 2 Oct. 1943.

23. Col. Cyrus S. Ewan, Adj., TS, Lowry Fld. to CG, AFTTC, Oct. 1943; 1st ind., Capt. A.S. Brown, Actg. AG, AFTTC to CG, AFTTC, 28 Oct. 1943; Capt. Robert L. Dunsch, Actg. Asst. Dir., Armament Dept., TS, Lowry Fld. to Dir. of Trng., TS, Lowry Fld., 27 Oct. 1943, cited in History of Lowry Field, 8 July-31 Dec. 1943, vol. 2, ch. 16, pp. 69-72.

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24. CG, AFTRC to CG, ..., 6 Oct. 1943 and 1st ind., Brig. Gen. ... Harper, TC/AS Tng. to CG, AFTRC, 15 Oct. 1943, in AAG 353 Armament Tng.

25. History of Lowry Field, 1 July-31 Dec. 1943, vol. 2, ch. 16, pp. 36-42; Circular Series 4-4-1, Lowry Fld. Armament Dept., 15, 26 Jan. 1944, quoted in ibid., 1 Jan.-30 June 1944, vol. 2, ch. 25, pp. 70-74.

26. Lowry Fld. to CG, WTTC, 29 Feb. 1944, cited in ibid., 1 Jan.-30 June 1944, vol. 2, ch. 22, pp. 9-10.

27. Hq. AFTRC to CG, WTTC, 29 March 1944, cited in ibid., pp. 19, 20.

28. Hq. AFTRC to CO, Lowry Fld., 29 March 1944, cited in History of Buckley Field, 1 Jan.-30 June 1944, p. 7; CG, AFTRC to CG, ..., 30 March 1944, in WTTC files.

29. Lowry Fld. to CG, WTTC, 22 April 1944, quoted in History of Lowry Field, Jan.-June 1944, vol. 2, ch. 22, pp. 24-25.

30. AFTRC to CG, WTTC, 12 April 1944, cited in ibid., p. 20.

31. AFTRC to CG, WTTC, 5 April 1944, cited in ibid., p. 29.

32. In ibid., p. 30.

33. From 3 July 1943 to 16 April 1944 a four-week "Special B-29 Armament Course" was conducted at Lowry to teach airplane mechanics, electrical specialists, and power plant specialists how to make minor adjustments of machine guns and central-fire-control equipment. Principal features included:

Subject	Hours
.50-Caliber Machine Gun	36
20-mm. Aircraft Cannon	36
Explosives and Ammunition and General	
Electric Remote Control Turret System	36
Bomb Racks and Bombing Equipment	30

In March 1944 the ... Bomber Command, which was charged with development of the B-29 training program, concluded that it might be better to cover the armament subjects in the course of flexible gunnery training. Accordingly, Lowry discontinued the B-29 armament course. History of Lowry Field, 1 July-31 Dec. 1943, vol. 2, ch. 16, pp. 1-45.

34. History of Lowry Field, 1 Jan.-29 Feb. 1945, p. 165.

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35. Ibid., 1 Nov.-31 Dec. 1944, pp. 165-166.

36. Col. L.O. Ryan, Deputy AC/AS Tng. to AC/AS OCR, 10 Feb. 1945, in AFOIG files.

37. History of Lowry Field, 1 March-30 April 1945, pp. 157-161.

38. For a description of the "Block system," see p. 44, this study.

39. CG, AAF to CG, AFTRC, 7 March 1945, in AFTRC files; History of Lowry Field, 1 March-30 April 1945, pp. 162, 163.

40. TC Memo 50-35-2, 29 Oct. 1945, in AFSHO files.

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Chapter IV

1. Lt. Col. Early [illegible] Duncan, Comdt., TS, Lowry Fld. to C/AC, 18 Sep. 1940, cited in History of Lowry Field Armament Dept., vol. 2, ch. 2, p. 154.

2. Exec., OCAC to Materiel Div., 5 Dec. 1940, quoted in ibid., p. 156.

3. Proceedings of a Board of Officers Convened at Lowry Field for the Purpose of Studying and Submitting Recommendations Relative to the Training of Maintenance Personnel for Power Operated Gun Turrets and Sights, 27 March 1941, reproduced in ibid., pp. 174-179.

4. Report of Capt. William F. Day to School Exec., TS, Lowry Fld., 21 May 1942, cited in ibid., p. 160.

5. Ibid., pp. 161-162.

6. Report on Power Operated Gun Turrets, by Maj. William F. Day, Supervisor, Power Turret Div., Lowry Fld. Armament Dept., 2 June 1942, reproduced in History of Lowry Field, 1942, vol. 2, ch. 6, p. 237. (Hereinafter cited as Major Day Report.)

7. Capt. William F. Day, Supervisor, Power Turret Phase, Armament Sch., Lowry Fld., to Director of Armament, 15 Nov. 1941, quoted in History of Lowry Field Armament Dept., vol. 2, ch. 2, p. 166.

8. CO, Lowry Fld. to CG, CTTC, 7 Oct. 1941, in AFCTC files.

9. CG, AC to CG, ACTTC, 30 Oct. 1941, in AFCTC files.

10. Major Day Report, pp. 238-39.

11. Memo, Supervisor, Power Operated Gun Turrets Div., Lowry Fld., to Dir. of Armament, 15 Nov. 1941, quoted in History of Lowry Field Armament Dept., vol. 2, ch. 2, pp. 168-69.

12. Daily Diary of Lowry Field Armament Dept., Dec. 1941, cited in History of Lowry Field, 1942, vol. 2, ch. 6, p. 199; CG, ACTTC to C/AC, 10 Dec. 1941, in AFCTC files.

13. Schedule of instruction, Power Turret Div., Lowry Fld., 13 Dec. 1942, reproduced in History of Lowry Field, 1942, vol. 2, ch. 3, pp. 200-28.

14. Schedule of instruction, Advanced Power Operated Gun Turret Course, TS, Lowry Fld., 8 Feb. 1943, reproduced in ibid., 1 Jan.-7 July 1943, vol. 2, ch. 11, pp. 205-22.

15. 1 X, CG, AFTC to CG, Ls, Lowry Fld., 4 Sep. 1943, cited in ibid., 8 July-31 Dec. 1943, vol. 2, ch. 17, p. 62.

16. Ibid., pp. 62-64.

17. Maj. Allen B. Black, Asst. AG, AFTC to CG, AFTC, 12 Oct. 1943; Maj. Cyrus S. Penn, Adj., TS, Lowry Fld. to CG, AFTC, 23 Oct. 1943 and syllabus, cited or reproduced in ibid., pp. 90-92.

18. 1st Lt. Clifford B. Loen, Armament Dept., Ts, Lowry Fld., to Dir., Lowry Fld. Armament Dept., 25 Oct. 1943, quoted in ibid., p. 94.

19. Maj. R.H. Sinnen, Dir., Lowry Fld. Armament Dept., to Dir. of Tng., Lowry Fld., 17 July 1943; Maj. John Lane, Dir., Lowry Fld. Armament Dept. to Dir. of Tng., Lowry Fld., 7 Oct. 1943; 2d ind., Capt. P. S. McCormon, Asst. AG, AFTRC, 21 Oct. 1943, all cited in ibid., pp. 103, 104.

20. TWX, Brig. Gen. Albert L. Sneed, CG, Lowry Fld. to Sperry Gyroscope Co., 9 Dec. 1943; and TWX, Gen. Sneed to CG, AFTC, 10 Dec. 1943, quoted in ibid., p. 105.

21. TWX, AFTRC to CG, AFTC, 16 Feb. 1944, cited in History of Lowry Field, Jan.-June 1944, vol. 2, ch. 23, p. 44.

22. Lowry Fld. to CG, AFTC, 29 Feb. 1944, cited in ibid., pp. 44, 45.

23. AFTC to CG, AFTC, 17 March 1944, quoted in ibid., vol. 8, ch. 2, pp. 20-21.

24. 2d ind., Lowry Fld. to AFTC, 11 April 1944 on ltr., Lowry Fld. to CG, AFTC, 14 March 1944; 2d ind., AFTRC to AFTC, 26 April 1944 on ltr., Lowry Fld. to CG, AFTC, 12 April 1944, all cited in ibid., vol. 2, ch. 23, pp. 38, 39.

25. AFTC to CG, Lowry Fld., 13 May 1944, cited in ibid., p. 22.

26. AFTC to CG, Lowry Fld., 20 May 1944, cited in ibid., p. 22.

27. Lowry Fld. to CG, TTC, 27 May 1944 and 1st ind., TTC to AFTRC, 5 June 1944, in AFTRC files.

28. 3d ind., Maj. Gen. [illegible] Harper, AC/S in to CG, AFTRC, 13 June 1944, in AFTRC files.

29. History of Lowry Field, 1 July-31 Aug. 1944, vol. 2, ch. 2, p. 5.

30. CG, AFTRC to CG, AAF, 23 Feb. 1945, in AFTRC files; AFTRC Mess numbers Progress report, 1 May 1945, in AFTRC files.

31. 1st ind., CG, AAF to CG, AFTRC, 15 May 1945, in AFTRC files; TC Memo 50-35-1, 10 Oct. 1945, in AFTRC files.

32. History of Armament Training School, 7 Dec. 1941-31 Dec. 1942, p. 32.

33. Ibid., 1 Jan.-7 July 1943, p. 22.

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