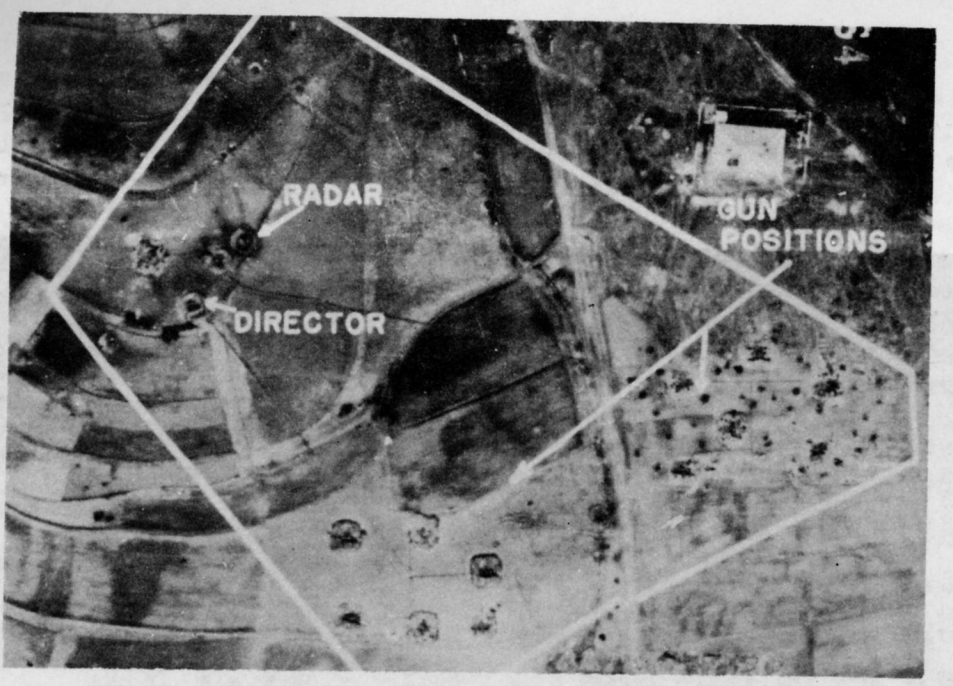
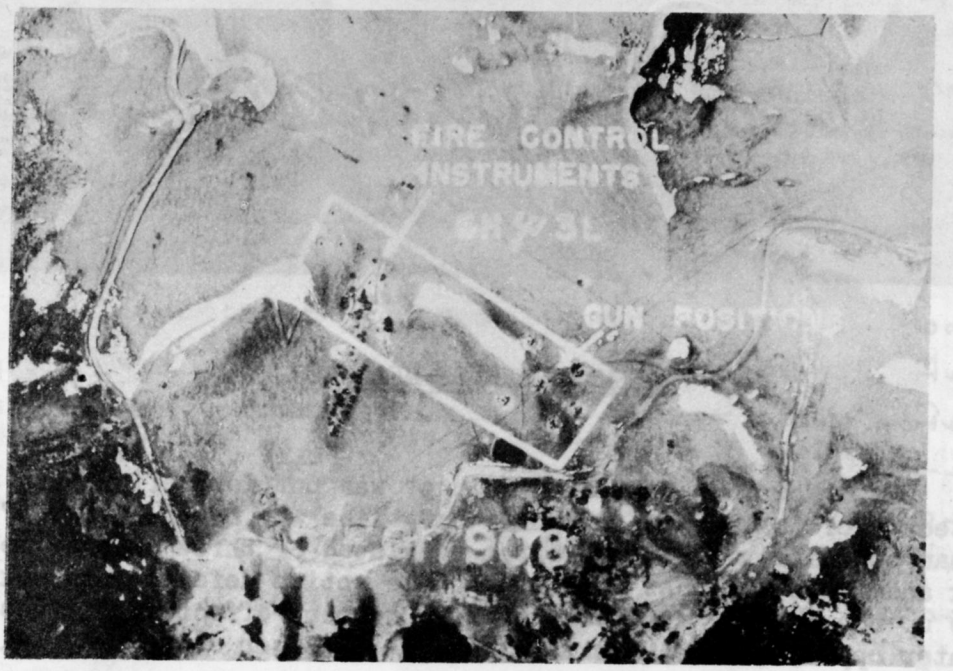
GERMAN DEFENSE MEASURES

On 6 November operation "Bingo" was put into effect and a concerted effort against the Brenner pass line was begun by the 57 Wing. German opposition to this program consisted of three defense measures. Flak and fighter planes constituted the active defense and smoke screens made up the passive defense. By far the most effective of these was flak; fighter opposition and smoke screens were a poor second and third.

On occasion our aircraft encountered a limited number of enemy fighter planes but they were usually driven off by the defenses of the formations and the escorting fighters before inflicting any damage. The largest part of the activity in Italy was carried out by the Second Group of the Italian Fascist Republic Air Force, its Italian pilots manning ME-109s with German markings. This Italian unit, which had about 50 aircraft at the beginning of our Brenner campaign, used five or six airfields



SIX HEAVY GUN BATTERY AT ALA



GROSSE BATTERIE AT CAMPO DI TRENS

These sites show typical layouts of Brenner line heavy anti-aircraft artillery guns and fire control instruments.

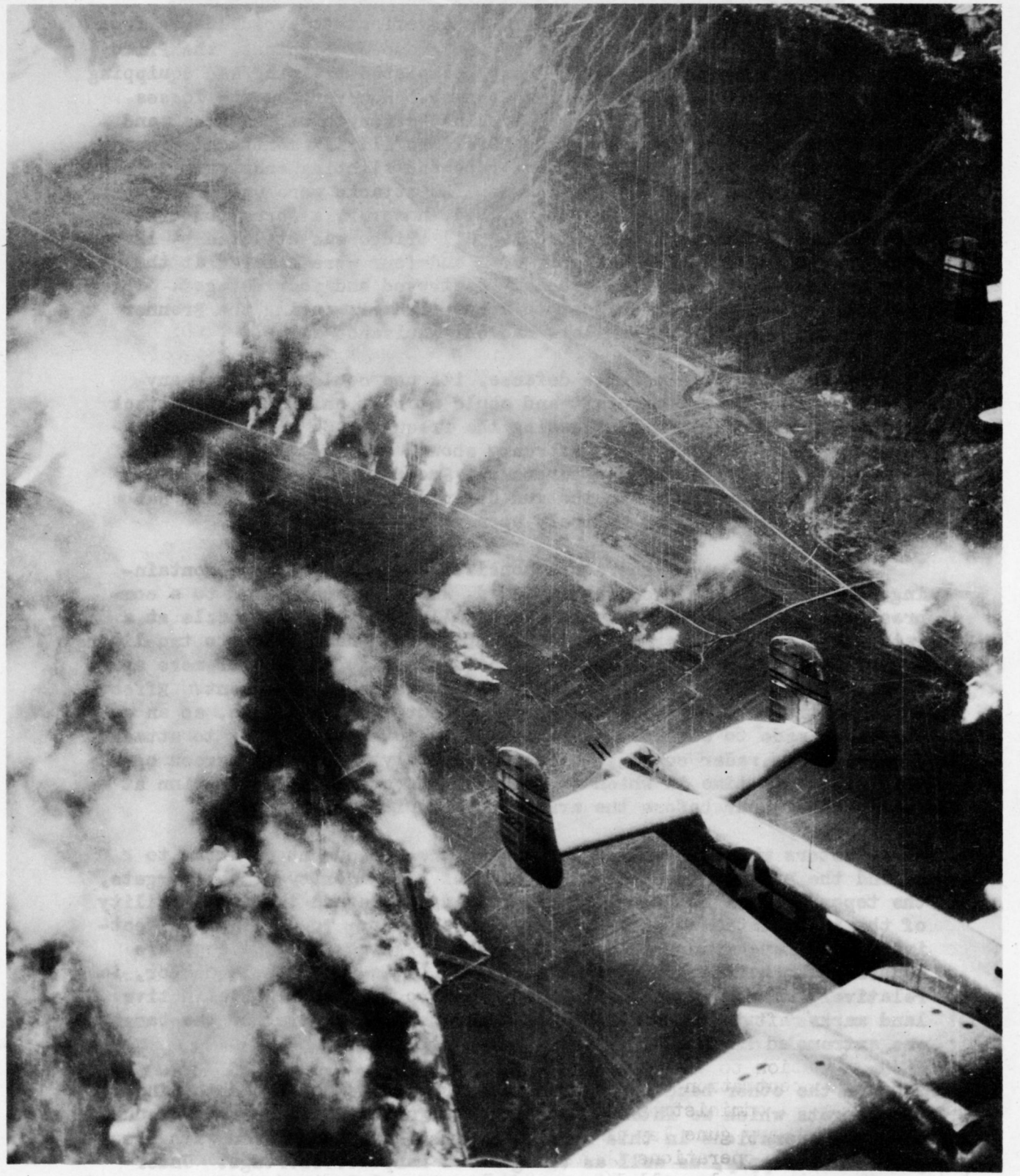
and dispersed their planes carefully in an effort to avoid losses from Allied attacks. During January a second group of fighters, the Primo Gruppo Caccia, or First Fighter Group, completed training and equipping and was brought back to Italy from Germany. However, due to losses suffered by the Second Group, the combined strength of the First and Second Groups was only about 55 ME-109s. In all six months of Brenner attacks by B-25s only 24 formations reported sighting enemy fighters and only 13 formations were attacked. The attacks were unaggressive for the most part. On 10 December, 1944, however, a formation of 17 aircraft on a mission to San Michele rail bridge was attacked by 12 to 15 ME-109s. One B-25 was shot down and four were damaged at the cost of four ME-109s destroyed, one probably destroyed and four damaged. This was the only medium bomber lost to enemy fighters during the Brenner campaign, as most of the attacks had only nuisance value.

Since smoke is a passive defense, its use could not cause any damage or loss to our aircraft and could at best only hold off attack until another day without affecting the frequency or magnitude of future attacks. January and February showed the most extensive use of smoke screens for defense purposes. Smoke was used at Verona and Rovereto as a supplement to the gun defenses while at Lavis and San Michele the enemy relied entirely upon smoke.

The Germans used generators consisting of a metal drum containing 40 gallons of chlorosulphonic acid, which was connected to a compressed air cylinder. The acid was expelled through the nozzle at a rate which could be varied as required from one-half liter to two liters per minute. Each generator was operated manually and one or more spare drums of acid was normally kept on hand for quick replacement. Effective densities could be accomplished in about twenty minutes, so an attempt was made to commence operation 30 to 40 minutes prior to attack. With complete radar coverage of northern Italy, the smoke screen operators had ample time in which to get the generators into operation at least a half-hour before the arrival of our formations.

Factors which aided the Germans in the employment of smoke to defend the Brenner were the small size of the majority of the targets, the topographical features, the prevailing winds and the accessibility of the installations to rail and road transport. To use smoke effectively, moderate winds, such as those in the Adige river valley, are necessary. The valley, especially in the Lavis-San Michele sector, is relatively narrow, which made it possible to blanket all distinctive land marks. Under such conditions accurate pin-pointing of the target was extremely difficult.

On the other hand the Germans had the problem of pre-determining the targets which we intended to attack. Furthermore, because of our numerous operations in this area, they must have been faced with the problem of supply, as well as the general manpower shortage. Under normal conditions smoke screens were placed so the heavy flak positions were not covered. This reduced the accuracy of fire greatly, since smoke coverage caused the gunners to rely entirely on unseen, or radar, fire-control, which is only about 25 per cent as accurate as visually controlled fire.

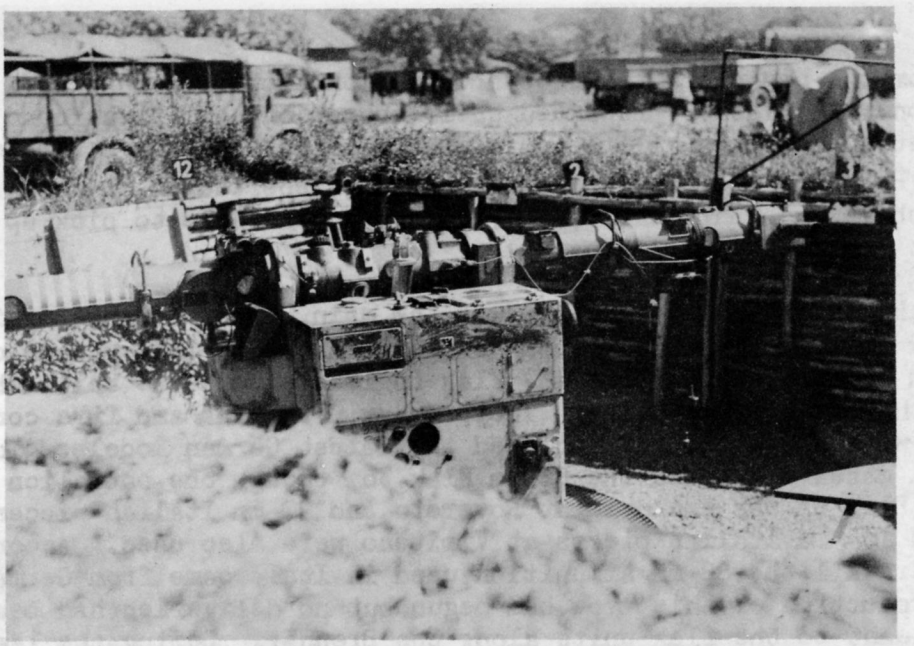


Though not a major threat smoke screens often made bombing difficult. This photo was taken at San Michele.

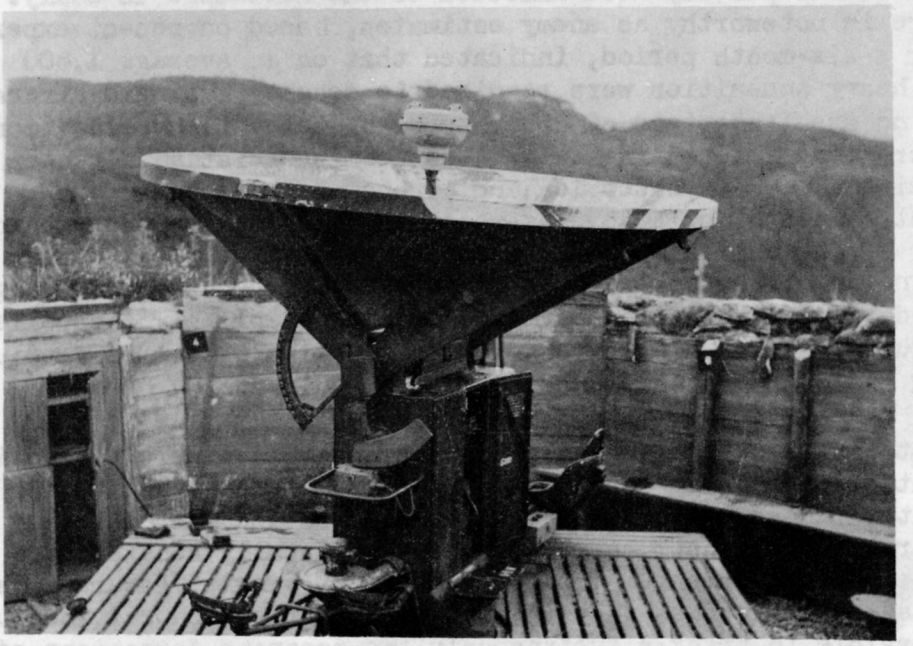
From the beginning the presence of smoke pots was reported. However, only 18 missions reported their operation, and five found coverage sufficiently complete and dense to interfere with accurate bombing. Probably its most effective use was reported on 22 January at San Michele when only three of 17 aircraft were able to pick up the target and drop their bombs.

Flak, as stated previously, was the main German defense against air attack and constituted the most serious threat to the success of our medium bombers. The 5 and 137 Flak Regiments were the units which defended the Brenner rail line. Their heavy flak guns and fire control equipment were excellent and included the latest German models. In almost all cases they used the 88-mm Flak 36, though one battalion of the 88-mm Flak 41 was employed at Rovereto and 90-mm Italian pieces at Verona and 105-mm Italian pieces at Vipiteno were also used. According to prisoners all the 88-mm ammunition used in Italy came from Germany. Italian production of this type had begun but no deliveries had been made, at least to the flak units along the Brenner. During the last months of the war a critical shortage of 88-mm ammunition developed and only 2,000 rounds per day were allotted to the Luftwaffe in Italy. This figure is noteworthy as enemy estimates, based on recent experience over a six-month period, indicated that on an average 1,600 rounds of heavy ammunition were required to destroy a single aircraft. There was no great shortage of other types of heavy flak ammunition, as they were manufactured in Italy. The Kommandogerat 40 director was used with all 88-mm batteries and if one of these units was knocked out, a spare, or KG36, was received as a replacement within a few hours. The delicate FMG 41 D radar was used with all heavy batteries north of the battle area and was relied upon for the range and altitude of the attacking formation. Fire completely controlled by radar was used only as a last resort. The Italian batteries also used the German radar though they used the Italian director.

Most flak installations along the Brenner line were formed into "Grosse Batterien", which consisted of two or more heavy batteries at one locality. These batteries were installed around the centrally located fire control instruments. The latter usually consisted of two complete sets of equipment. The most important single feature inherent in a "Grosse Batterie" was that the two sets of fire control instruments made it possible to track simultaneously two separate formations of attacking aircraft, one with each set, permitting the fire of the guns to be transferred rapidly, by means of the Rhonrad switching device, from one formation to the other. In addition, these large flak sites afforded a concentration of fire power, and simplified repair, maintenance, supply and administration. The greatest weakness of such a concentration of heavy guns lay in the fact that it provided a larger target for anti-flak operations than was provided by independently sited batteries. For example, all 16 guns at Rovereto were located at one site. As proof of the successes of our anti-flak operations, these 16 guns, after being bombed, were split into two batteries of eight guns each.



KOMMANDOGERÄT 40



FLAKMESSGERÄT 41-D

These fire control instruments, photographed at Bolzano, were standard and were typical of installations on the Brenner. The Kommandogerät 40 is the latest model of German director. It is a mechanical calculator with stereoscopic height finder incorporated, capable of predicting a rectilinear or curvilinear course. The Flakmessgerat 41-D, gun laying radar is one of the latest German models, capable of furnishing present azimuth, angular height and range to the director. More accurate visual tracking was used to furnish azimuth and angular height when possible. Radar range, however, is more accurate than stereoscopic range. Note the strong revetments which are typical of those built around the dug-in guns and instruments.

The gun, director and radar emplacements of all batteries were heavily revetted for protection of equipment and crews. When it was possible to make a suitable drainage ditch to keep the emplacement from filling up with water the positions were dug in approximately one-half below ground level. When the gun position was in a low place where it could not be conveniently drained it was built above ground.

The terrain on the Brenner presented difficulties to the German flak units as well as to the attacking aircraft. There were relatively few positions where high mountains did not restrict fields of fire or interrupt radar reception. This made it impossible to emplace guns at San Michele, for example, or to rearrange the position of the defending guns at several other targets. The lack of motor fuel and the great amount of preparation necessary to emplace a heavy battery properly were other factors which limited the movement of batteries.

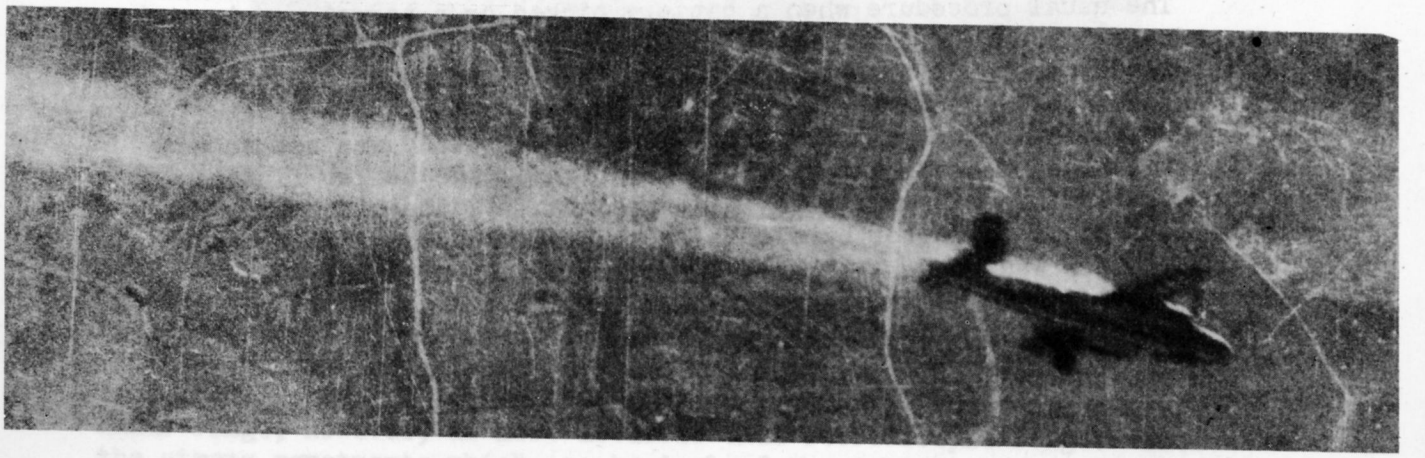
Since the capitulation German officers have stated that they always had warning of our bombing attacks. Our radio transmissions were monitored by listening posts along the Po and it was nearly always possible to detect aircraft taking off on a mission. The information obtained at the radio listening posts or by radar was telephoned and radioed to the fighter control room at Verona. There it passed through a filter room where it was evaluated and forwarded to the plotting room. In the plotting room a large vertical map was kept showing the location, course, altitude and number of aircraft operating over Italy. When a formation approached within 200 kilometers of a defended area, its position was radioed and telephoned to the area "Flakfuehrer". The "Flakfuehrer" of the defended area in turn pre-alerted his heavy gun batteries, and his crews prepared to man their apons and instruments. If the formation approached within 80 kilometers of the area the alert was given. At that time the approximate course and altitude of the formation was relayed to the battery commander. The crews manned the weapons and instruments, checked orientation and synchronization, and made ready to commence firing as soon as the range was favorable.

The usual procedure when a battery picked up a target was to use radar tracking for range and optical tracking for direction. The height finder operator tracked the target in his instruments but this data was not used unless the radar became unreliable because of chaff or some other interference. In that event the altitude was set so as to remain constant until data could be sent in by the height finder, a process requiring approximately five seconds. If the aircraft was obscured from the director by clouds or white phosphorous smoke, one of two methods was used. Either the radar was used to supply all elements of data to the director or barrage fire was used. In either case the accuracy of the battery was reduced.

Defended areas were divided into sectors, one for each battery. The battery commander was free to fire on any hostile aircraft that entered the sector of the defense assigned to his battery; however, the "Flakfuehrer" ordered fire on aircraft not in his sector. It was general practice for batteries to fire on aircraft only as long as they were approaching a target. The data from the radar were plotted on a board to give the battery commander a graphical picture of the situation. It was common practice for data from neighboring batteries to be plotted on the board.

The personnel manning the Luftwaffe flak batteries were ordinarily 60 to 70 per cent German and 30 to 40 per cent Italian. The batteries at Verona were the exception, in that they were manned entirely by Italians. The majority of the German personnel had several years of experience with their equipment and was well trained and capable, though their average age was high. However, there had been some turnover in German personnel when men overage in more active units were transferred into the flak units in exchange for younger men. Turnover of Italian personnel was very high and as a result their state of training was usually low.

The Battle of the Brenner started with approximately 366 heavy guns from Verona to Innsbruck. All of these were concentrated around the four key points of Verona, Trento, Bolzano and Innsbruck. Attacks early in November and the operation "Bingo", which forced conversion from electric to steam power, convinced the Germans that attacks would continue. They immediately started building up the defenses by adding guns and redeploying others. By 7 November guns were in operation at Ala and Rovereto. Attacks of the first two weeks were confined to the lower Brenner between Verona and Trento. During this period six batteries, 42 guns, were added, but the overall Brenner line defenses remained substantially the same, as those above Trento were reduced. By 11 November, for example, enough guns had been moved to new positions that, of 18 B-25s on a mission to the Calliano rail bridge, nine aircraft were holed and one crash-landed as a result of heavy, intense, accurate flak all the way from Verona to Ala.

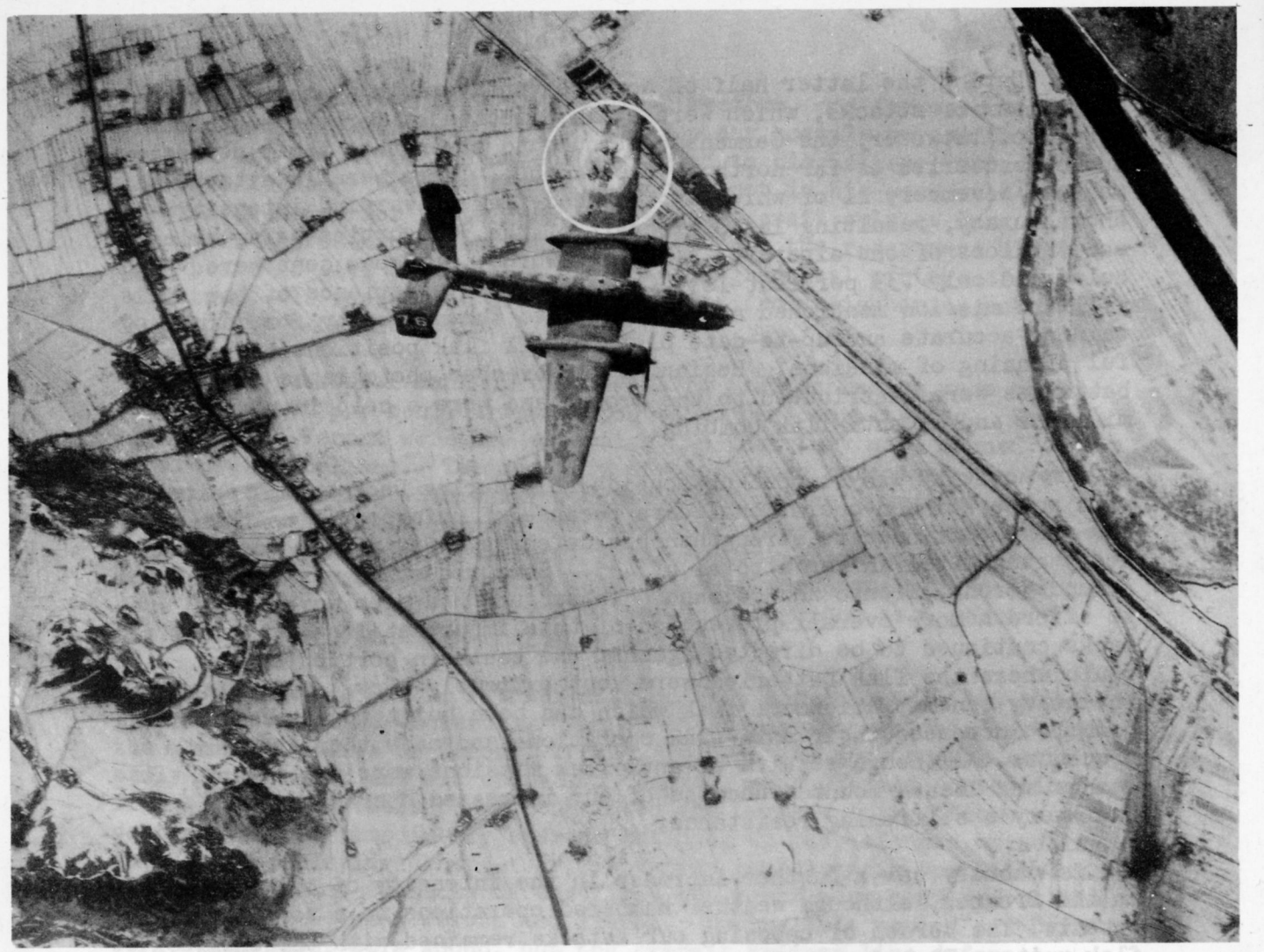


During the latter half of November unfavorable weather reduced the number of attacks, which were again directed at targets south of Rovereto. However, the Germans continued to strengthen their defenses, adding batteries as far north as Bressanone. There were 16 attacks made in November, 11 of which experienced flak of varying intensity and accuracy, resulting in 20 aircraft of the 300 sorties being holed and the loss of one aircraft. In other words, 6.67 per cent were holed and only .33 per cent lost. However, the experience of the Calliano mission mentioned above emphasized the necessity for maintaining accurate and up-to-date plots of all flak positions and careful planning of missions. Beginning in November photographs of flak batteries were distributed to the groups and were a help in planning missions and in anti-flak bombing.

Activity was stepped up considerably during December in spite of a number of non-operational days because of unfavorable weather. The enemy continued to strengthen his defenses. Sixty-nine additional heavy guns moved in for a total of 435. Some reduction was noted around Verona, Trento and Bolzano. These guns had been moved north to afford a more overall protection of this important line. All attacks continued to be directed against the southern portion of the route where the flak batteries were kept extremely busy. To counter the heavy concentrations of flak which had been built up, the medium bombers increased their anti-flak operations and made them standard procedure. Although results of anti-flak missions were gratifying, damage and losses mounted because of our increased operations and the enemy's stiffening resistance.

January saw a further increase in the intensity of our attacks on the Brenner, although weather hampered operations to a considerable extent. The burden of opposing our attacks remained with the enemy flak units. Flak-free routes to and from the targets were used which required anti-flak measures only immediately before and after the bomb run when the formations were actually within range of the guns protecting our targets. About the first of the year Air Crew Flak maps, 1:1,000,000 scale, began to be distributed in quantity to the groups for each navigator and lead pilot. The scale was ideal for use in aircraft. They proved especially useful on long range missions where any condition such as poor weather forced formations off their briefed courses. They also served as a reminder of dangerous areas pointed out in briefings. Selection of these routes and the use of anti-flak measures accounted for a continued saving to our aircraft and personnel.

The flak defenses along the Brenner pass route continued to increase slightly, although the main German effort at improving their effectiveness was in shifting the guns to more advantageous locations. A number of batteries were placed along the roads in the mountains as high above sea level as the Germans could get them. Considering the altitudes from which the B-25s bombed, this did not materially increase the range of the guns, but it did serve to eliminate some of the blind spots caused by the mountains. Also, batteries located in these rough, out-of-the-way places were difficult for anti-flak bombers to find. Batteries at Trento, Bressanone and Ponte All'Isarco were each about 3,000 feet above sea-level, while one west of Ala was approximately 4,100 feet high.



Heavy, intense and accurate flak, encountered throughout the bombing breakaway, on the 7 February attack on the Lavis rail viaduct, accounted for the large hole in the left wing of this B-25. Although reported losing altitude when last seen near the target, the plane flew for one hour and 20 minutes before the entire crew bailed out safely over Switzerland.

In January the total number of guns at Bressanone rose from 22 to 34 while at Trento the number rose from 24 to 32. Eight guns were removed from Bolzano, probably to Ora, while San Ambrogio also lost eight, probably to Verona, where an increase of eight was noted. The total for the whole route rose by 40 to 475 heavy anti-aircraft guns. Fifty-eight missions were flown, comprising 1,250 sorties. Of these, 39 formations were subjected to flak which damaged 224 B-25s (17.92 per cent) and caused the loss of five aircraft (.40 per cent).

In February the organization of the defenses against our extensive aerial operations continued to be the main problem confronting the German flak units. The gunners were being forced to share the strain of combat since their batteries were constantly brought under direct attack. Both B-25s and fighter bombers were being used to destroy and harass flak units. No longer were units, placed outside the normal bomb pattern area, safe. It seemed that the enemy was making a frantic search for something new to bolster his defenses. Reports of what were thought to be rocket projectiles and other types of pyrotechnics came from crew members on several occasions. Since the surrender, however, German prisoners have denied that they ever used anything but the usual type of projectile with either black or red bursts.

As a result of the increased flak defenses and the successes achieved on the lower Brenner, our bombers began attacking bridges further to the north. To counter this, more batteries from the southern section of the line were shifted north. This was evidenced by the removal of the following guns: 24 from Peschiera, six from Belluno Veronese, and six of 18 from Brantino Belluno. Decreases of six at Bolzano and 10 at Ora were also made. On the other hand the number of heavy guns at Trento rose from 32 to 42, at Laion from six to 16, and at Bressanone from 34 to 44. New batteries also appeared, including 12 heavy guns at Castelrotto, 20 heavy guns at Lavis and four heavy guns at Brennero. At San Michele a certain amount of anti-aircraft protection was received for the first time from these new guns at Lavis. As a result our B-25s experienced more opposition when attacking the San Michele bridge than formerly. The overall change was an addition of seven heavy guns, making a total for the line of 482. This was more than one-half of all the remaining guns in Italy.

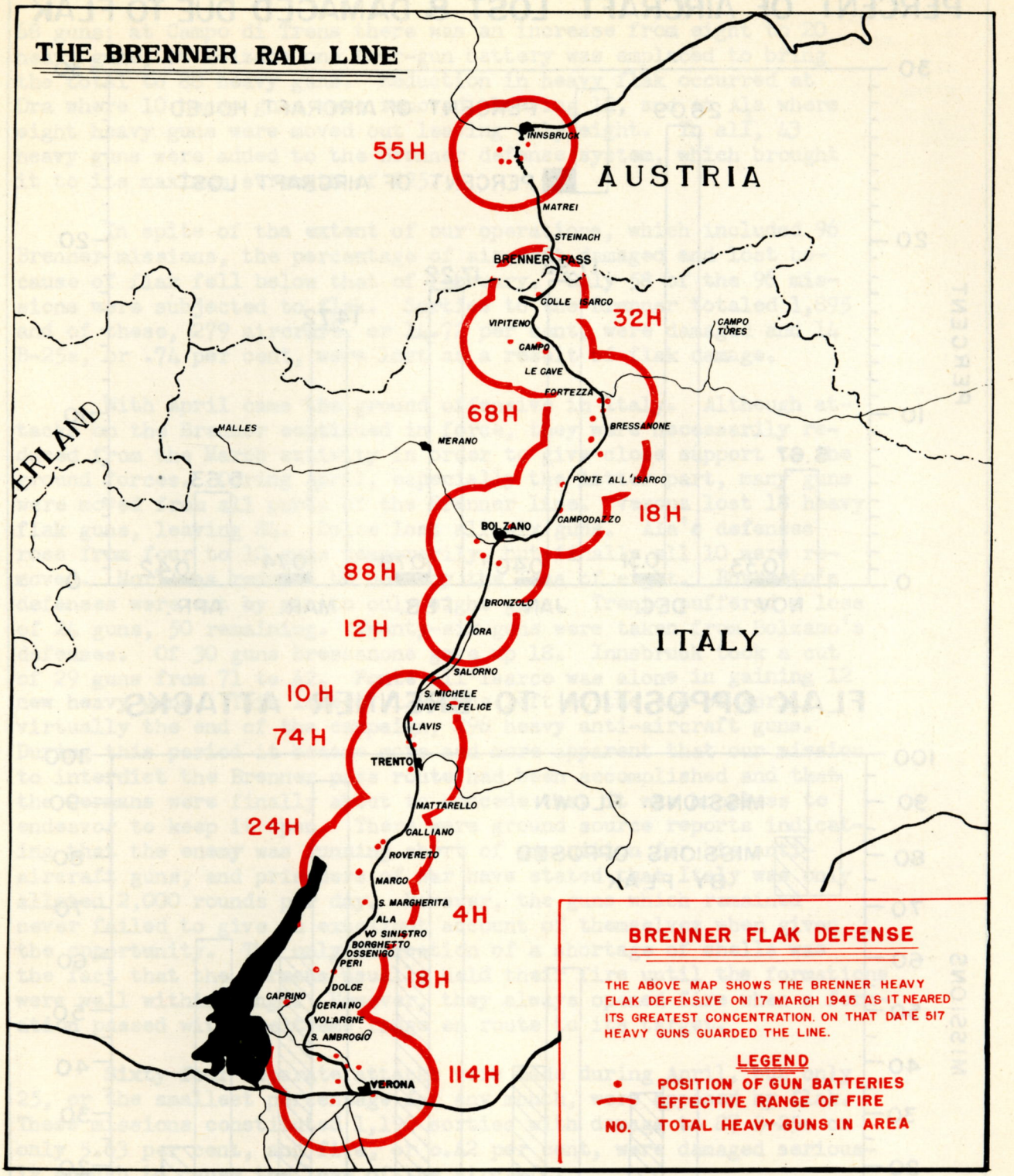
The stepped-up frequency of the medium bomber attacks during February is indicated by 82 missions flown against Brenner pass route targets. These comprised 1,771 sorties. Of the 82 attacks, 62 were subjected to anti-aircraft fire which caused damage to 305 B-25s (17.22 per cent) and resulted in the loss of 14 aircraft (.79 per cent).

The peak in intensity of our bombing was reached during the month of March when excellent weather prevailed. The continued careful selection of targets, planning of flak-free routes, flak evasion tactics and anti-flak measures paid large dividends. March not only saw the greatest number of Brenner attacks, but also the selection of targets was extended to those on the upper Brenner, including targets in Austria for the first time. This was done both to extend the zone of interdiction and also to find undefended targets. While every effort was made to find flak-free targets, it should be pointed out that this consideration did not prevent formations from being dispatched if the destruction of a target were essential. In addition, no formation was ever turned back by intense, accurate flak without dropping its bombs.

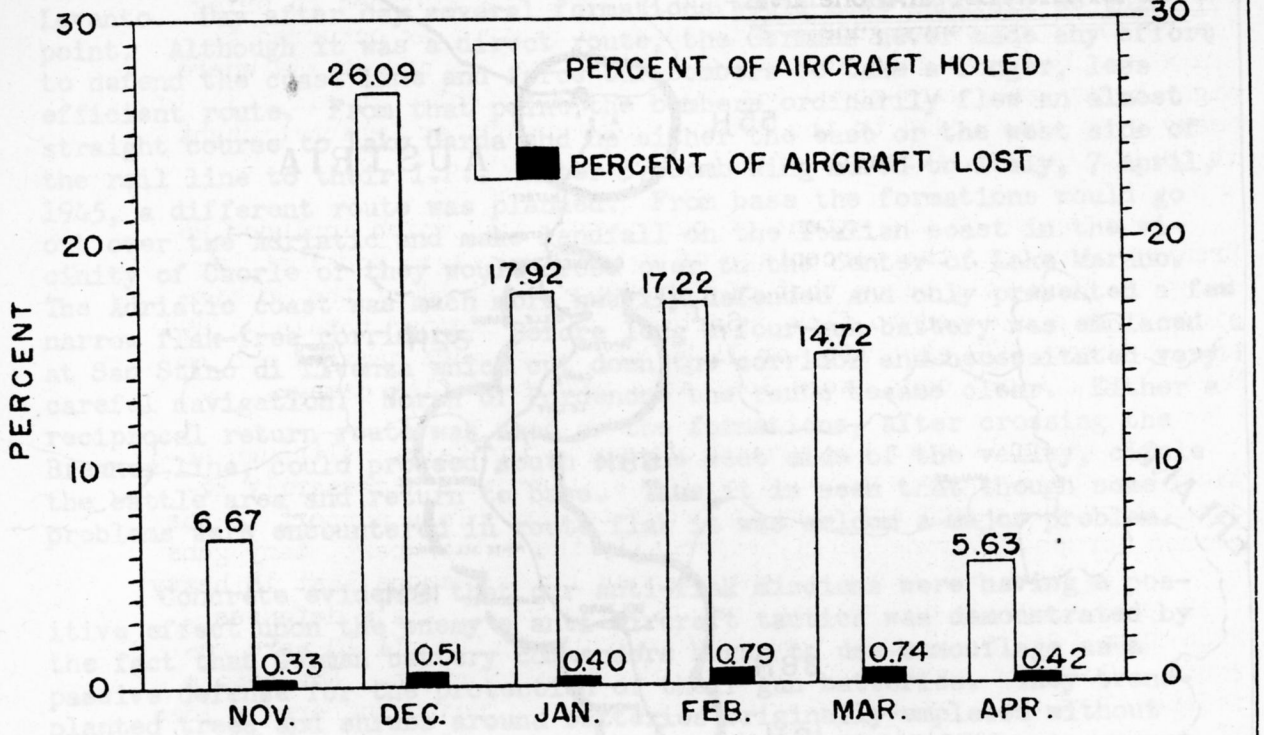
As long as our bombers were based on Corsica, they almost invariably followed a route to and from the Brenner which crossed the coast near Levanto. Day after day several formations would make landfall at this point. Although it was a direct route, the Germans never made any effort to defend the coast line and force our bombers to take a longer, less efficient route. From that point the bombers ordinarily flew an almost straight course to Lake Garda and up either the east or the west side of the rail line to their I.P.. After 57 Bomb Wing moved to Italy, 7 April, 1945, a different route was planned. From base the formations would go out over the Adriatic and make landfall on the Italian coast in the vicinity of Caorle or they would cross over to the center of Lake Marano. The Adriatic coast was much more heavily defended and only presented a few narrow flak-free corridors. Before long a four-gun battery was emplaced at San Stino di Livenza which cut down the corridor and necessitated very careful navigation. North of Pordenone the route became clear. Either a reciprocal return route was used or the formations, after crossing the Brenner line, could proceed south on the west side of the valley, circle the battle area and return to base. Thus it is seen that though some problems were encountered in route flak it was seldom a major problem.

Concrete evidence that our anti-flak missions were having a positive effect upon the enemy's anti-aircraft tactics was demonstrated by the fact that German battery commanders began to use camouflage as a passive defense for the protection of their gun batteries. They transplanted trees and shrubs around batteries originally emplaced without any form of camouflage. Since this type of camouflage does not present much of an obstacle to accurate photo interpretation, it was evident that the enemy hoped to confuse or mislead the bombardier in the anti-flak element by increasing the problem of target recognition. A strikin example of tree camouflage and a demonstration of the enemy's intent to reduce the effectiveness of anti-flak bombing was shown north of Lavis. On 26 February, photo interpretation showed the six-gun position to be entirely without camouflage. On 7 March a different story was revealed when photos showed the original guns still present, four additional guns and the entire position skillfully shrouded by a seemingly natural continuation of a nearby forest. Obviously this deception did not mislead photo interpretation, but it was confusing to a flight whose mission was to shower the position with well-placed phosphorus bombs. Other batteries along the Brenner line later resorted to the same type of camouflage. At Campo an eight gun battery and later an additional six gun battery employed tree camouflage. An eight gun battery at Vipiteno and a position of 12 heavy guns at Bressanone likewise adopted this type of deception. Reports of the Germans' employment of various unusual types of flak continued to come in during March but again none of our aircraft suffered damage from these strange bursts.

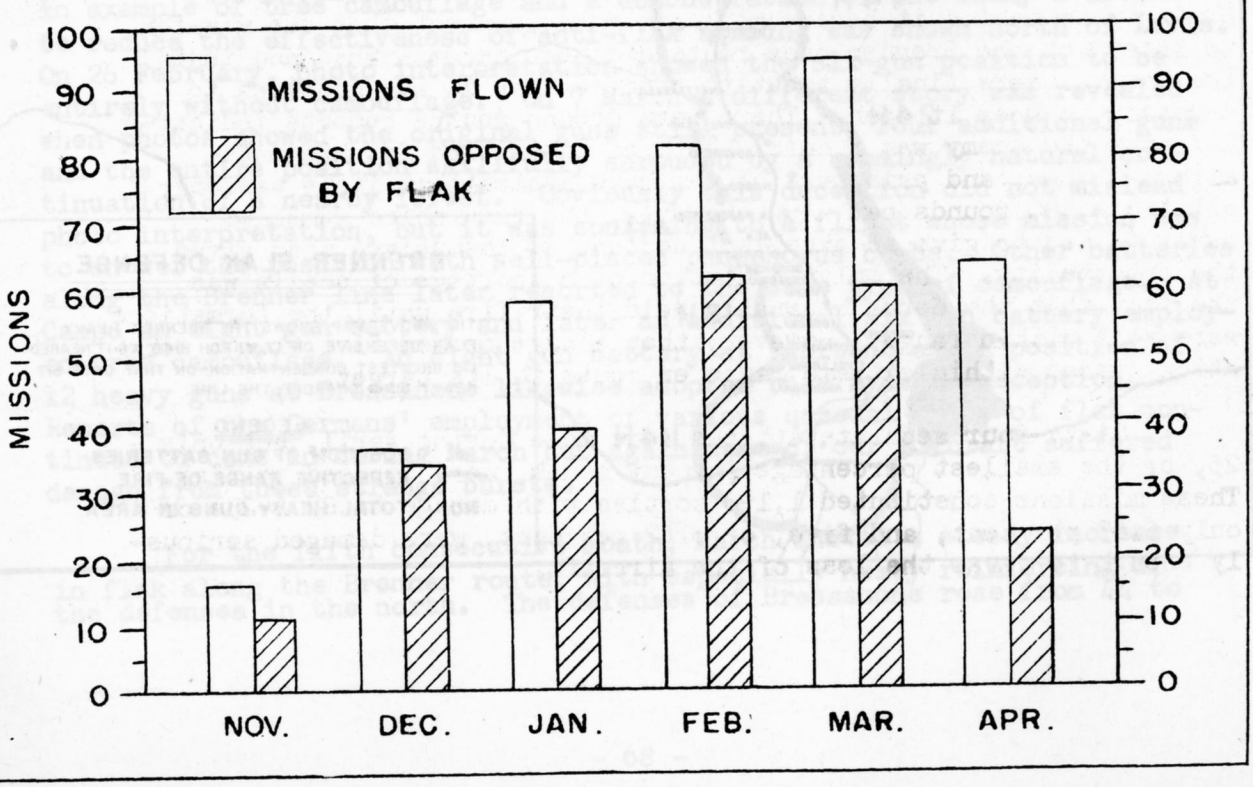
For the fifth consecutive month, March showed a steady increase in flak along the Brenner route, with especially heavy reinforcing of the defenses in the north. The defenses of Bressanone rose from 44 to


THE BRENNER RAIL LINE
55H
AUSTRIA
INNSBRUCK
MATREI
STEINACH
BRENNER PASS
COLLE ISARCO
32H
VIPITENO
CAMPO TURES
CAMPO
LE CAVE
FORTEZZA
68H
MALLES
MERANO
BRESSANONE
PONTE ALL'ISARCO
18H
CAMPODAZZO
BOLZANO
88H
BRONZOLO
12H
ORA
ITALY
SALORNO
10H
S. MICHELE
NAVE S. FELICE
74H
LAVIS
TRENTO
MATTARELLO
24H
CALLIANO
ROVERETO
MARCO
S. MARGHERITA
4H
ALA
VO SINISTRO
BORGHETTO
OSSENIGO
PERI
18H
DOLCE
CAPRINO
CERAINO
VOLARGNE
S. AMBROGIO
114H
VERONA
BRENNER FLAK DEFENSE
THE ABOVE MAP SHOWS THE BRENNER HEAVY FLAK DEFENSIVE ON 17 MARCH 1945 AS IT NEARED ITS GREATEST CONCENTRATION. ON THAT DATE 517 HEAVY GUNS GUARDED THE LINE.
LEGEND
POSITION OF GUN BATTERIES
EFFECTIVE RANGE OF FIRE
NO. TOTAL HEAVY GUNS IN AREA

PERCENT OF AIRCRAFT LOST & DAMAGED DUE TO FLAK



FLAK OPPOSITION TO BRENNER ATTACKS



68 guns; at Campo di Trens there was an increase from eight to 20 heavy guns; at Bolzano one four-gun battery was emplaced to bring the total to 88 heavy guns. Reduction in heavy flak occurred at Ora where 10 heavy guns were removed, leaving 12, and at Ala where eight heavy guns were moved out leaving only eight. In all, 43 heavy guns were added to the Brenner defense system, which brought it to its maximum strength of 525.

In spite of the extent of our operations, which included 96 Brenner missions, the percentage of aircraft damaged and lost because of flak fell below that of February. Only 58 of the 96 missions were subjected to flak. Sorties to the Brenner totaled 1,895 and of these, 279 aircraft, or 14.72 per cent, were damaged and 14 B-25s, or .74 per cent, were lost as a result of flak damage.

With April came the ground offensive in Italy. Although attacks on the Brenner continued in force, they were necessarily reduced from the March activity in order to give close support to the ground forces. During April, especially the latter part, many guns were moved from all parts of the Brenner line. Verona lost 18 heavy flak guns, leaving 84. Dolce lost all six guns. Ala's defenses rose from four to 10 guns temporarily, but finally all 10 were removed. Mori was reduced to none by the loss of eight. Rovereto's defenses were cut by six to only eight guns. Trento suffered a loss of 24 guns, 50 remaining. Twenty-six guns were taken from Bolzano's defenses. Of 30 guns Bressanone gave up 18. Innsbruck took a cut of 29 guns from 71 to 42. Ponte All'Isarco was alone in gaining 12 new heavy guns. This loss of 129 guns left at the end of April, virtually the end of the campaign, 296 heavy anti-aircraft guns. During this period it became more and more apparent that our mission to interdict the Brenner pass route had been accomplished and that the Germans were finally about to concede that it was hopeless to endeavor to keep it open. There were ground source reports indicating that the enemy was running short of ammunition for his anti-aircraft guns, and prisoners of war have stated that Italy was only alloted 2,000 rounds per day. However, the guns which remained never failed to give an excellent account of themselves when given the opportunity. The only indication of a shortage of shells was the fact that the Germans usually held their fire until the formations were well within range. However, they always opened fire when a formation passed within extreme range en route to its target.

Sixty-four separate attacks were made during April, but only 25, or the smallest percentage for any month, were opposed by flak. These missions constituted 1,190 sorties with damage to 87 B-25s or only 5.63 per cent, and five, or o.42 per cent, were damaged seriously enough to cause the loss of the aircraft.

Throughout the entire six months of the campaign against the Brenner, the Germans continually improved their defenses and at the same time our effort was doubled and redoubled. In almost all instances the type of fire used by the enemy was "continuously pointed" which is the most effective type. Only rarely, when phosphorus smoke interfered with visual tracking but the gun positions were not directly hit, were there any reports of the less effective types of fire, either "predicted concentration" or "barrage", being resorted to by the Germans. Regardless of these facts, it should be noted that for the last three months the percentage of missions encountering flak was reduced. Also percentage of aircraft damaged showed a decline each month since December. A loss of less than one per cent was maintained throughout. This record can only be attributed to the careful study of the enemy's flak potential by operations and intelligence personnel which made possible the correct selection of targets, the planning of flak-free routes to and from the targets, the best possible evasive tactics at the target and the employment of the most effective anti-flak measures consistent with accurate bombing.

The mission of flak intelligence was accomplished by means of a broad program. Most of the factual information as to the exact number and location of gun positions originated with photographic interpretation in the Third Photographic Group Reconnaissance as directed by the Mediterranean Allied Tactical Air Force. This was augmented by interpretation of bomb strike photos within the groups and Wing and by interrogation of crew members. The information was compiled and continually kept up to date by all units. Flak maps, scale 1:100,000 were periodically published by the Third Photo Group as a check on the uniformity of the records of these units. Air Crew Flak maps, scale 1:1,000,000, were also published by the Third Photographic Group from time to time as changes in the situation warranted their issue. The up-to-the-minute situation was kept readily available and posted on large war-room flak maps for use in planning all phases of future missions. Analyses of gun defenses were made for all targets where deemed necessary. Records of flak experiences and statistics of results of all missions were kept for future planning. The results achieved in the interdiction campaign of the vital Brenner pass line and the saving in crews and aircraft amply justified this expenditure of effort by flak intelligence personnel.

ENEMY MAINTENANCE

Our interdiction program on the Brenner was hindered by the natural difficulties of terrain and weather. Of the active defensive measures taken by the enemy, flak was constantly dangerous and smoke-screens and fighters were occasionally a threat. Our last major adversary was the enemy's repair system. In the early days of the attacks on rail communications it had not been necessary for the enemy to devote large numbers of men and quantities of equipment to rail maintenance and repairs. However, as the attacks moved north and bombing accuracy reached its peak, it became necessary for the enemy to develop a large and complex system of rail repair and maintenance. It was to be expected that the enemy's greatest repair effort should be expended on the Brenner pass line.

In general, bridges were the most difficult part of the rail line to repair. Experience showed that the higher the bridge and the longer the span, the more difficult and lengthy were repairs. Bridges

in Italy 60 to 70 feet high and with a span length of over 90 feet presented a serious problem to repair crews, because it was difficult to construct piers of that height. Unfortunately there were no bridges of this type on the Brenner; as a result even if a bridge were destroyed, repair crews were seldom faced with a lengthy or difficult repair job.

On the Brenner line the enemy maintained a well-equipped and well-manned repair organization. His units were dispersed over the line in such a way that specific points of damage could be reached in the shortest possible time. In addition repair trains were employed to rush men and equipment to blocks in the line. According to prisoner of war information and analysis by photographic interpretation these trains were made up approximately as follows:

1. One car for administration and repair files and from three to nine expert technicians.

2. Two to four workshop cars for welding equipment, tools, spare parts, switches, etc.

3. One to two cars for quarters and kitchen facilities.

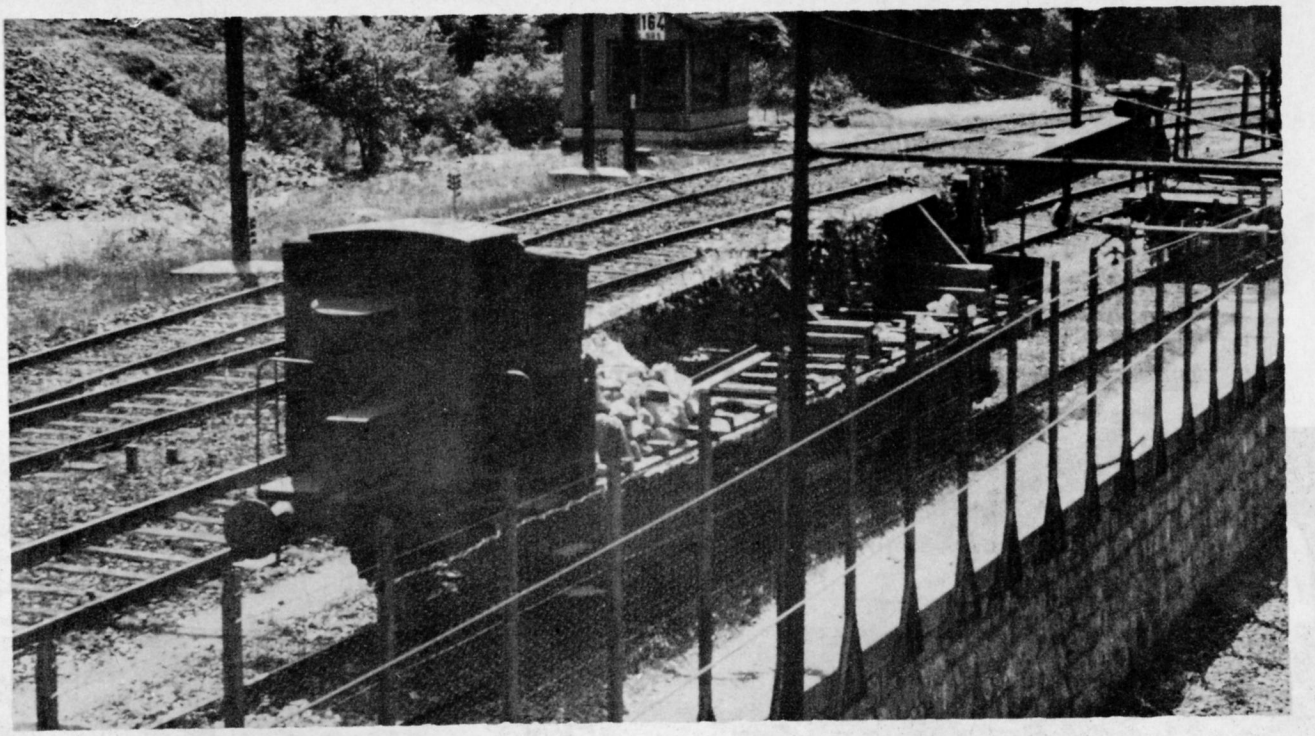
4. One to two flat cars for spare rails and ties and girders and other replacement parts.

5. One to two hopper cars for cement, gravel and stone blocks, for fill and track bed construction.

It was reported that often two trains approached the damaged area from either side, so that work could begin on each side of the damaged section simultaneously. In some cases small emergency trains carrying unskilled workers were dispatched to the scene of damage prior to the completely equipped train; in such a case they cleared the rubble and completed other preparatory tasks, enabling the repairs to begin immediately upon the arrival of the expert crews.

The railway crane, one of the most important pieces of repair equipment, was invaluable in handling heavy spans or prefabricated piers. The typical crane featured a long boom, varying in length from 100 to 150 feet. One or sometimes two standard flat cars, in addition to the cab car which housed the machinery, were usually distinguishable at the base of the boom. The long shadow cast by the boom when mounted was distinctive and facilitated its identification. When in a traveling position the boom was lowered on flat cars. Its shadow in this position is similar to that of a girder, and unless the photographs were of large scale it was difficult to recognize.

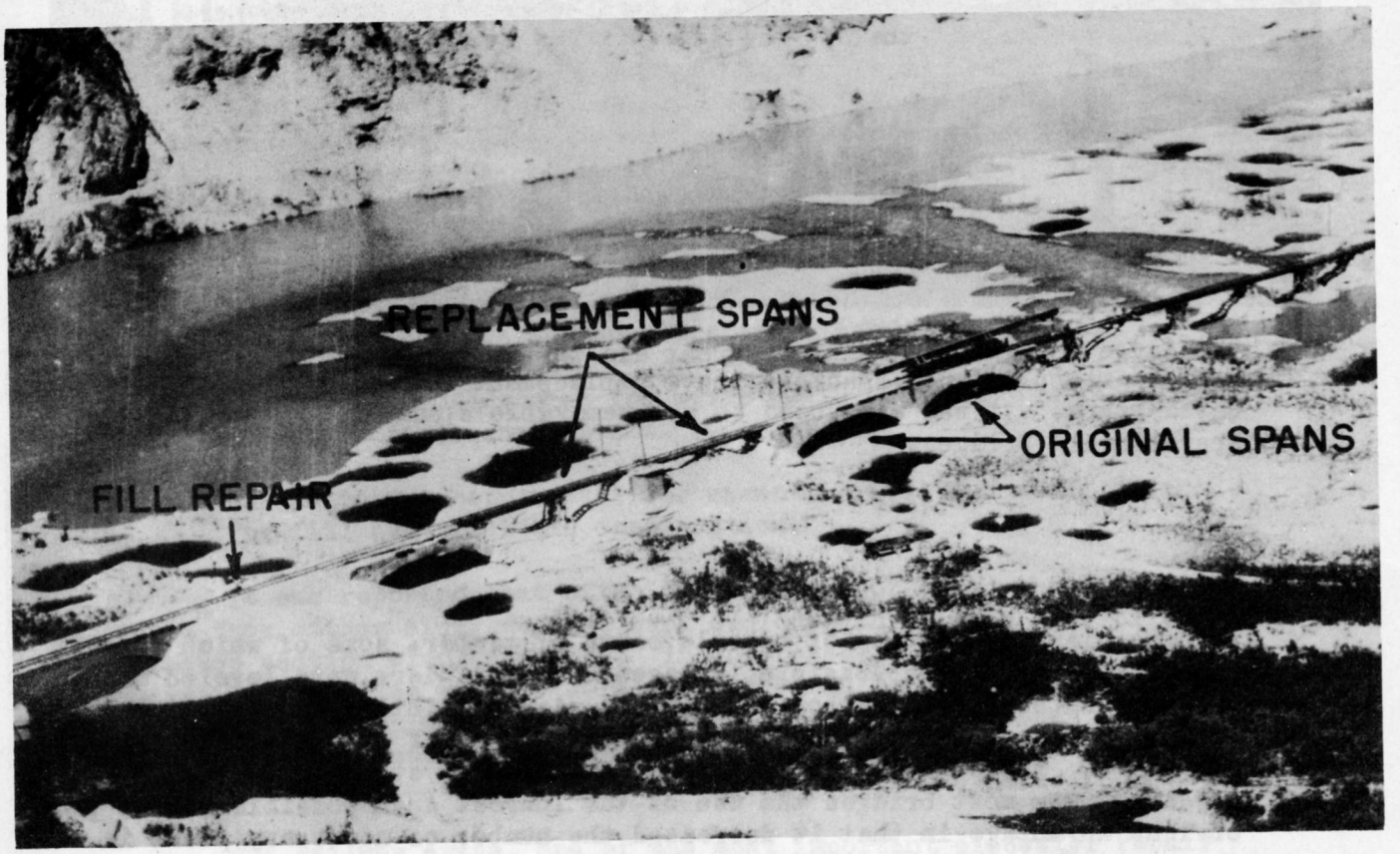
Repairs to piers were the most difficult part of bridge repair and were accomplished in most cases by the erection of sub-



The large railroad crane was a great aid to the enemy in bridge repair, particularly in handling heavy replacement spans and prefabricated piers. It was also used to set removable spans in "night operational" bridges.

stitute piers consisting of trestle bents of timber, some of which were pre-fabricated. When possible, damaged original piers were leveled and trestle bents placed thereon or a wooden pier consisting of crosslaying of timbers was built to the desired height on top of the cleared original piers. These substitute piers were spanned by steel I-beams or girders. For most bridges the use of the longest span possible had an obvious advantage in that it decreased the number of necessary piers in the gap. The advantage thus gained was appreciable, since the most difficult and lengthy job in bridge repair was the erection of the piers. A long span had its limitations, however, since its weight increased out of proportion to its length. Not only did this involve economy in the use of steel, but eliminated setting a large, heavy span in place. In north Italy, it was found that the length of span varied, in general, directly with the height of the pier. For bridges on the Brenner the length of span most commonly utilized was between 40 and 60 feet. This was apparently the longest girder which could be readily handled with available equipment, and which still reduced the number of piers to be erected following an attack. In a few cases destroyed spans crossing dry river beds were replaced by fills. The advantage gained here, notably at Lavis and Calliano, was that fills were considerably easier to repair than bridges.

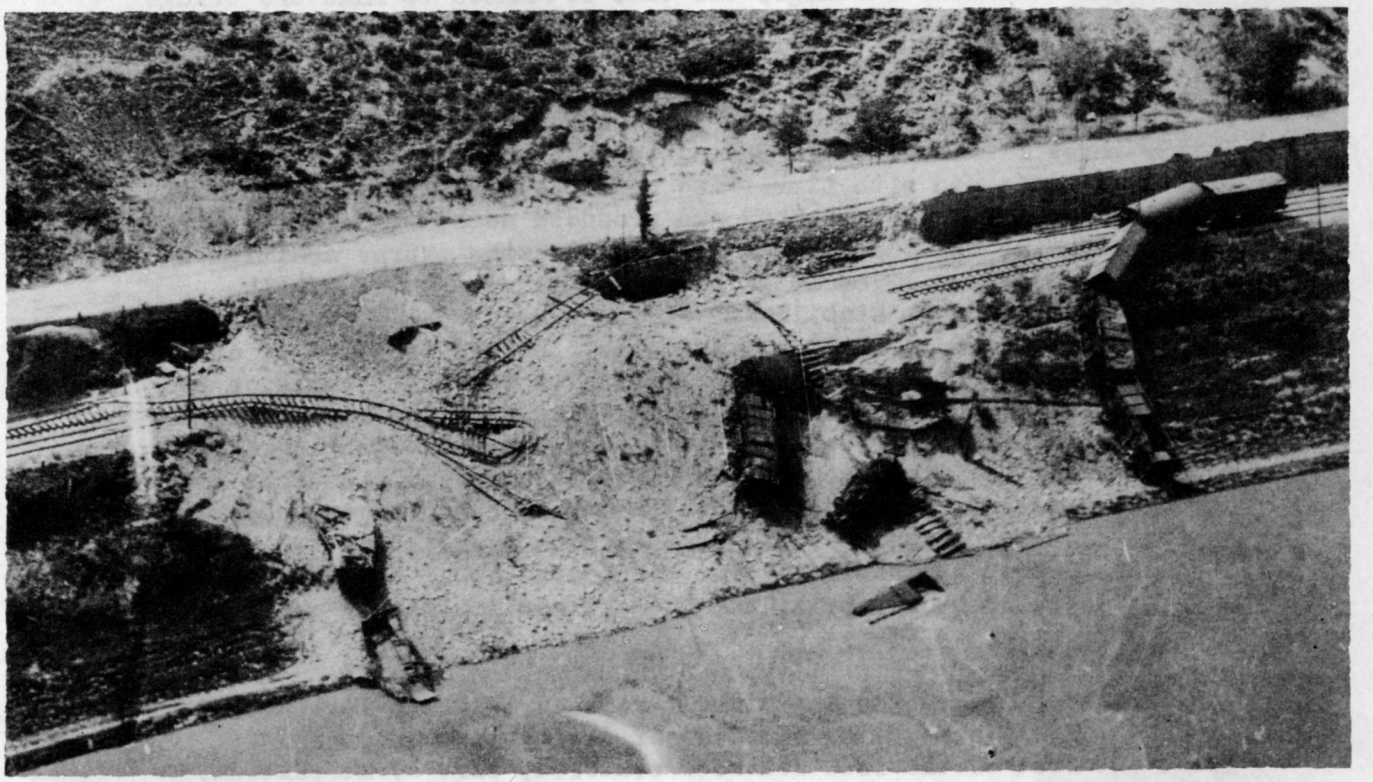
As a general rule repair on the Brenner enjoyed a first priority in the enemy's repair efforts and it was not until March and April, 1945, that it definitely appeared that the large number of attacks was swamping the enemy's repair facilities. There were cases, notably at the Lavis viaduct and San Michele bridge, where repairs lagged considerably but it will be remembered that these targets were by-passed with diversions. The first priority repair effort was generally expended on the diversions as they were in all cases easier to repair.



The Lavis viaduct offers an interesting study of Brenner bridge repairs. In the center of the above photograph are seen two of the original 35 masonry spans. Farther to the left two original spans have been destroyed and replaced by typical repair spans. These spans are approximately 40 feet long, are made of steel I-beams and are supported at their junction by trestle bents. The destroyed span at the left of the photo has been replaced by a fill. Note that the joint pier of two replacement spans is supported by a fill.

Because of flak and terrain difficulties and the small number of suitable medium bombardment targets, our interdiction program on the Brenner was of necessity based, first, on the destruction of small bridges and, second, on the cratering of fills. As a general rule it may be said that four to seven days were required to repair a typical Brenner bridge if one or more spans and an included pier were destroyed. There were a few examples at Vipiteno, Rovereto and Calliano when

damage was more rapidly repaired; in a few cases repair required more than seven days. However, a four to seven day repair expectancy proved reliable. Fills and cratered approaches to bridges could be repaired in only a few hours and under normal conditions did not require more than 24 hours to repair. Exceptions to this general rule were observed throughout the winter and increased in March and April. Fills very heavily cratered with six or eight or more direct hits often required more than 24 hours to repair. When a large number of attacks fell along a short section of line, the same delay was often noted. Such a condition delayed repairs, as crews were forced to start at the ends and work toward the middle of the damaged section, and it also overburdened existing repair facilities in the immediate area of the points of damage. Pre-fabricated bridge sections were occasionally used to span craters, notably at Rovereto and San Michele.



This photograph shows a lower Brenner fill cut by a direct hit. Damage of this type target was repaired in a few hours.

Two factors contributed to the repair difficulties the enemy encountered in March and April. First was the increased tempo of our attacks, which overburdened existing repair facilities and greatly extended the area of repair. Second was the spring high-water table which imposed severe difficulties on repair crews in their effort to stabilize cratered rail fills and approaches. In

the spring rain water and melted snow from the slope along the Brenner line caused a considerable rise in the level of the Adige river and its tributary streams and canals. In certain cases, when the flat valley floor lacked natural drainage, a high-water table resulted. The San Michele north rail bridge is a good example of the difficulties encountered in repairing lines where water-logged conditions existed. This bridge was a single-span, 100-foot steel girder bridge. Both approaches were over embankments. It was attacked on 31 March when the following damage was inflicted: the north abutment was destroyed; the 100-foot span was severely damaged; the approaches were cratered. By 4 April the damaged span had been removed and the north abutment rebuilt and set forward 50 feet from its original position. The south approach was repaired and craters in north approach were approximately half-filled. The north and south abutments were again destroyed on 4 April and approaches again cratered. Based on previous experience with repair to similar damage, the time estimated to make the bridge serviceable was three to four days. However, on cover 8 April the ground was still water-logged and seven gondolas loaded with coarse ballast for the rail bed had been moved up to the south approach. On 12 April it was seen that of the seven ballast wagons present on 8 April, three remained. This indicated that some ballast was used, probably reinforced with timber and rails, as was the general rule in such cases, but was absorbed and produced no stabilizing effect. The repair time was extended an additional week. Three additional ballast wagons were moved in on 12 April making a total of six present, but still no stabilizing effect was noted. Between photo cover of 18 and 20 April it appeared that the construction of abutments had been completed and some filling of the south approach had been made. On 22 April no additional repair progress had been made but the high water was beginning to recede and the water-logged condition was no longer acute. By 24 April the single 50-foot span had been laid and filling of the north approach had begun; however, no further progress on the fill of the south approach was noted. It was estimated at this date that the bridge could possibly be made serviceable by 25 April, but it remained impassable until the end of the war.

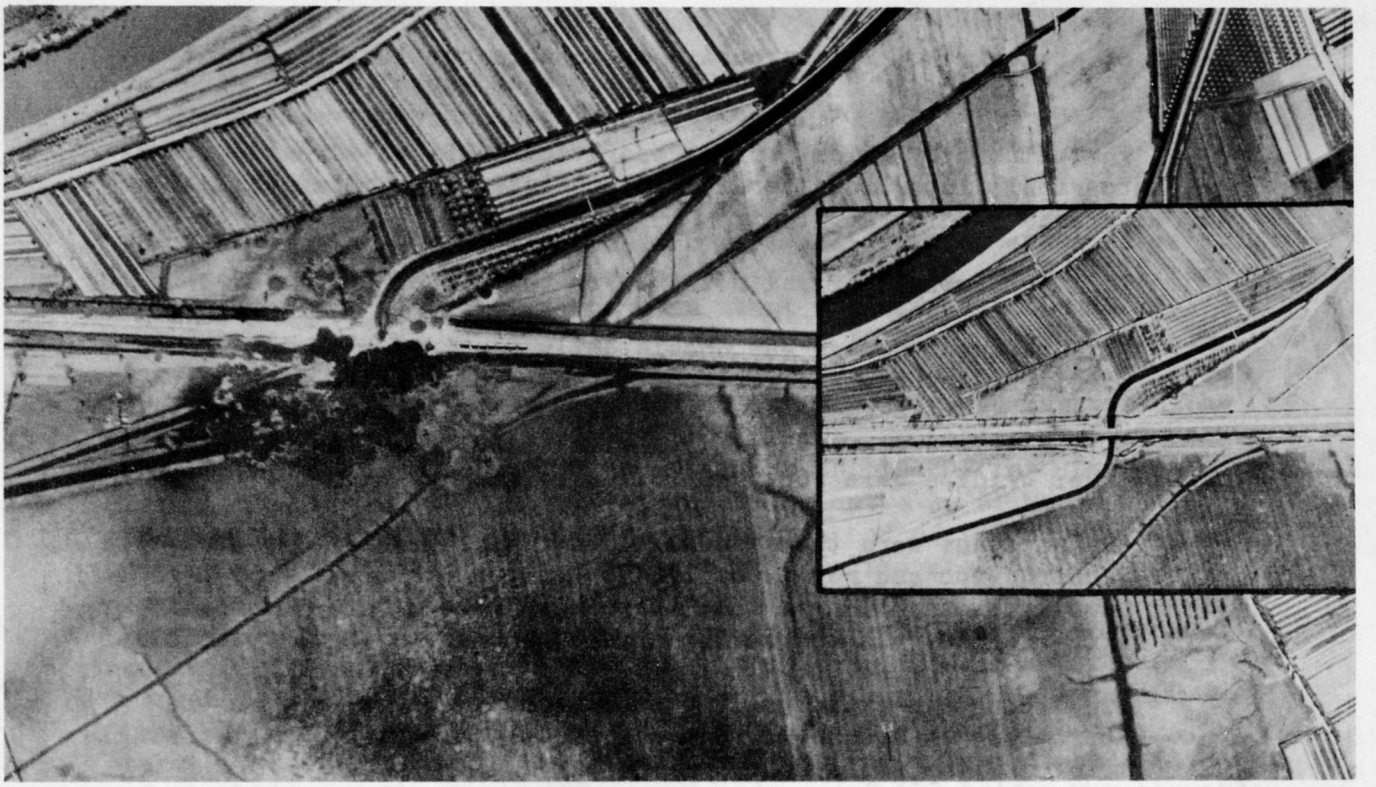
Photographs of the San Michele rail diversion bridge dated 17 March, 1945, showed the same repair difficulty encountered. About 400 feet of the fill had been cratered, part of it that day and part by previous attacks. Though repairs were started by the following day, they still had not been completed by the end of the month. On photo cover of 30 March it was seen that a new rail bed was being built alongside the badly mauled existing bed. This, together with the water-filled craters and the water-logged appearance of the fill, was regarded as strong indication that the extreme slowness of repairs could be attributed to the enemy's inability to provide a satisfactory foundation for the rail bed. By 2 April the new rail bed had been almost repaired, though the tracks were not laid, and it appeared as though it were being allowed to dry before

The top photo shows Campo rail bridge prior to attack by B-25s. The second photo shows the destroyed bridge the day after the successful attack on 21 April. The bottom photo shows the bridge repaired and passable nine days later. Repairs here were carried out by the typical construction of an intermediate pier and the laying of 60-foot repair spans.

subjecting it to rail traffic. It was attacked the same day, however, and on several subsequent days within a week. On 11 April repairs were again pressed, and finally on 17 April the line was made serviceable after having been out for over a month. Similar water-logged conditions were noted elsewhere on the Ora-San Michele complex, notably at the Salorno fill and Salorno station bridge. By attacking these two targets the San Michele block received additional reinforcement. To a lesser extent the same condition was noted at Rovereto on the lower Brenner. Although part of the slowness of repair in the illustrations may well be attributed to the overall strain put on the enemy's facilities, no small part of the delay in repairing certain cratered apprpaches and fills on the Brenner line can be attributed to the water-logged condition of the soil.

In the case of bridges that were particularly vulnerable because of their height or length, considerable emphasis was placed on the construction of diversions by-passing these vulnerable targets. On the middle Brenner, between Trento and Bolzano, diversions were built at Lavis, between San Michele and Ora, and at Bolzano. The absence of diversions south of Trento is explained in part by the existence of a by-pass line from Trento southeast to Cittadella and, more important, by the presence of short, easily repaired bridges in this section.

The construction of the Lavis diversion was begun in May, 1944, and completed by October, 1944. It was built to by-pass the vulnerable 35-span viaduct at Lavis. Over 90 per cent of the diversion was across easily repaired fill, and two short spans, separated by an island, across the water-gaps were the only vulnerable part of the diversion. The spans of this diversion bridge were supported at short intervals by timber piers set on mud-sills to insure their stability. The advantage of this type of construction was that a long bridge structure was eliminated by the fill embankments over the dry river bed. In addition, short piers, roughly four to six feet over mean water level, were relatively easy to erect and, because the spans were short, could be bridged by light structural members. It was found that cuts in the embankment were repaired in a very few hours, while a single hit on the structure, assuming a pier was destroyed, could be repaired in about one week. The 15-mile Ora-San Michele rail diversion, built along the east bank of the Adige river, reportedly by the cumulative efforts of 5,000 men, was completed on 6 December. Unfortunately the diversion offered few vulnerable targets. The most-attacked target on the diversion line was the San Michele rail diversion bridge. At first the damage inflicted here was quickly repaired and craters in the embanked approaches were filled within a few hours. Fill material for the embankment was accessible at a nearby stone quarry, and the low trestle bents and short spans required could be replaced within approximately three days. Later, however, considerable repair difficulty was encountered because of repeated attacks which pulverized the road bed and surrounding area, and the water-logged condition of the soil.



The 60-foot San Michele north bridge was destroyed by B-25s on 5 April. The insert above shows the bridge prior to attack. Repair at this target was hindered by the water-logged condition of the ground. Note water in the craters.

It is undoubtedly true that advantages accrued to the enemy by his use of diversions as a countermeasure. As a replacement bridge, the diversion's most appreciable value to the enemy was that it provided a structure which, because of short-span low-silhouetted construction, could be built in less time than it would take to restore the original bridge. When it was damaged it could be quickly repaired by the use of relatively light, easily-handled materials and standard repair methods. In addition the presence of a diversion required that two bridges be cut to block the line effectively.

The increase in tempo of our attack on the Brenner line was partially met by an attempted deception in the form of night operational bridges. These were bridges from which spans were removed to make them appear unserviceable, but which were quickly made serviceable again at such time as was desired. Because of the missing spans, these bridges appeared to be damaged to our air crews who, unless they had been briefed on this deception, might have withheld attack in

favor of attacking other obviously serviceable but less important bridges.

The pattern by which a night operational bridge revealed itself to photographic interpretation was so consistently similar as to make its existence readily apparent:

1. It was usually first detected by removal of a span or spans.

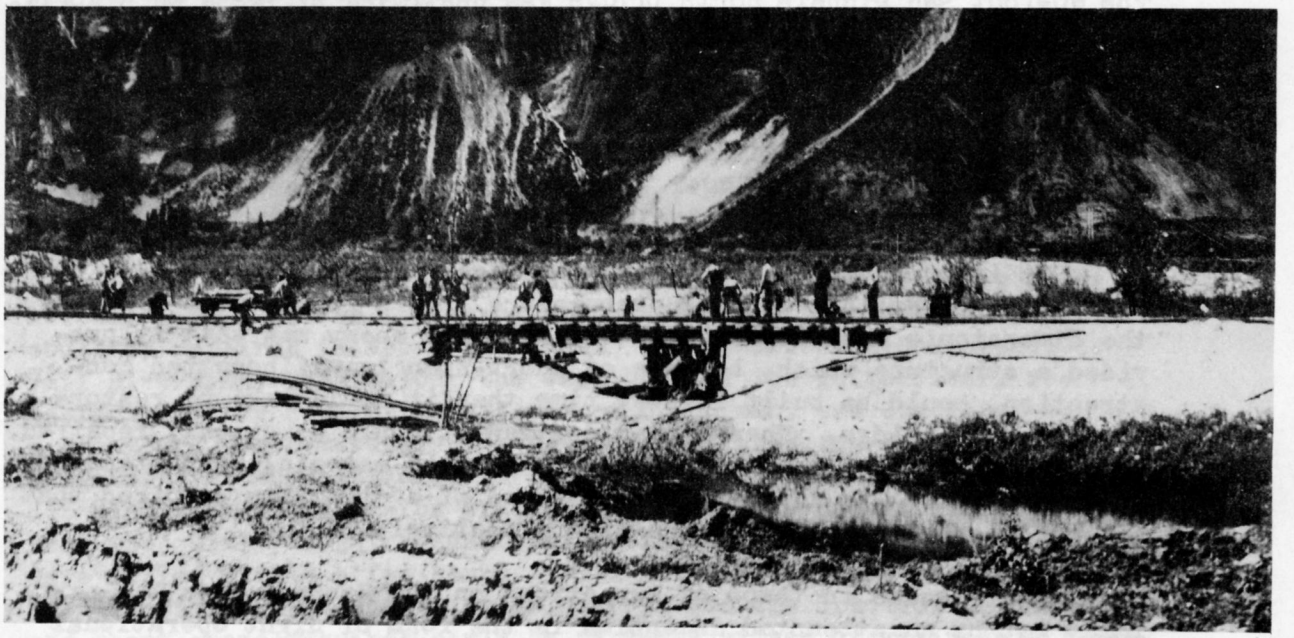
2. Subsequent damage was consistently repaired although the missing span or spans were not replaced during the day.

3. The bridge was invariably a vital link in a line on which all other bridges were repaired following attack.

4. The spans were the standard girder type used by the enemy for construction and repair of bridges on the Brenner. They were usually of such length that they could either be set manually or with a crane. In the latter case, the crane was often visible.

5. Although inactive rolling stock was sometimes kept on the approaches to create the impression of a block, at least a single track was kept clear.

6. Activity studies showed movement of rolling stock on the lines on either side of the bridge.

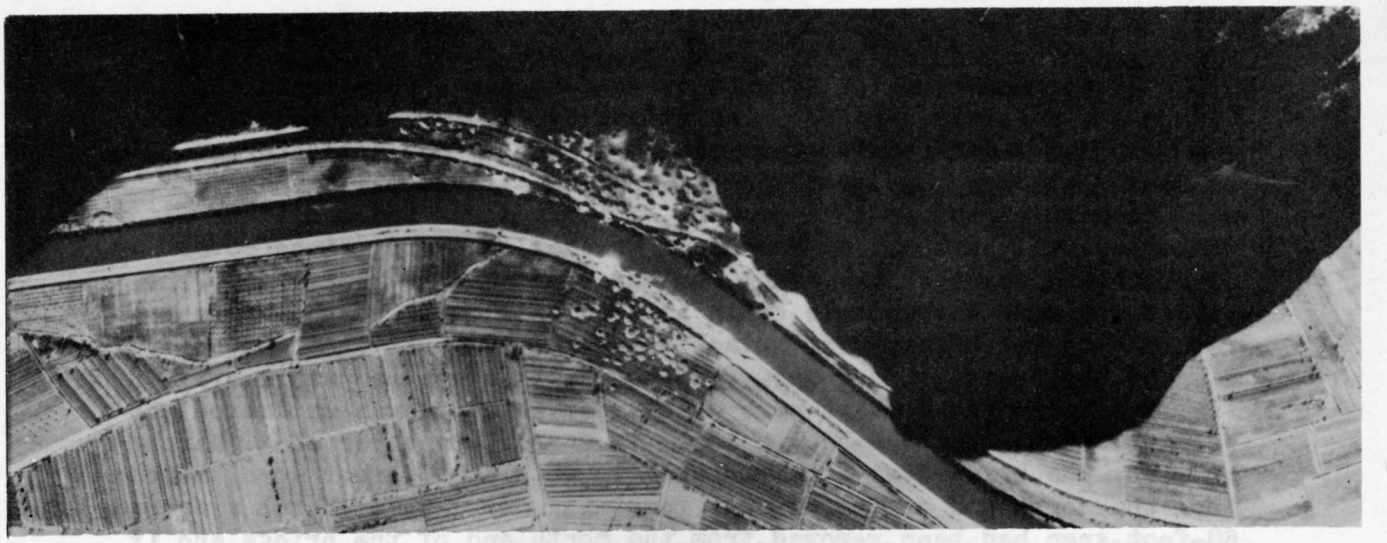


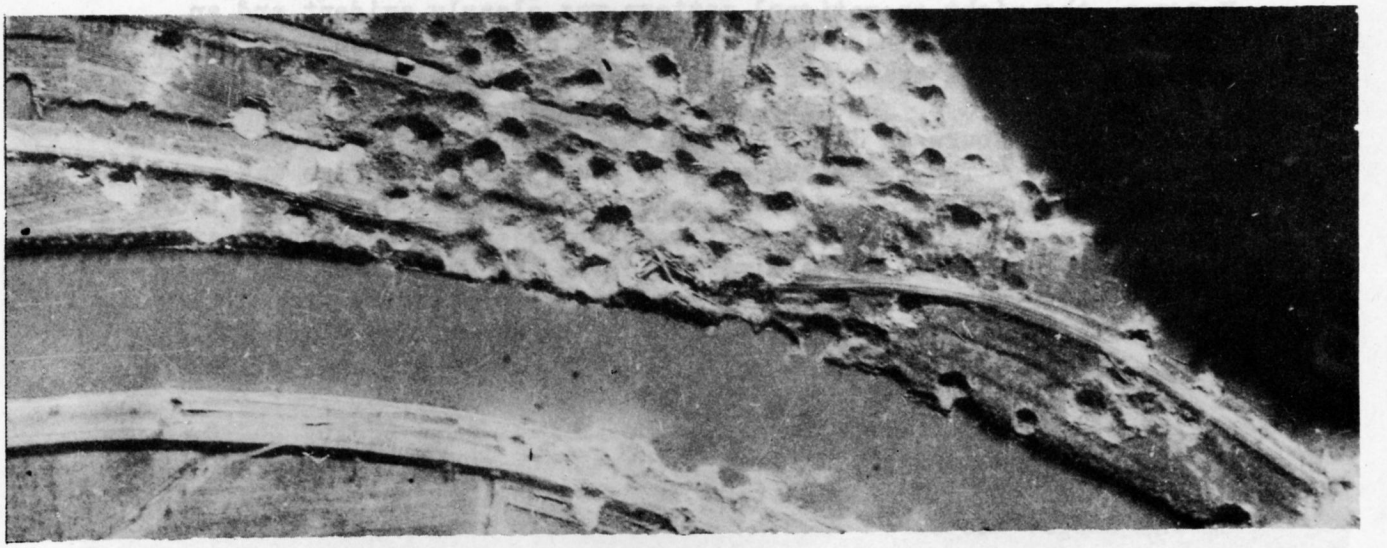
Short spans, such as this one on the lower Brenner, were sometimes employed to bridge craters in an unstable rail bed.

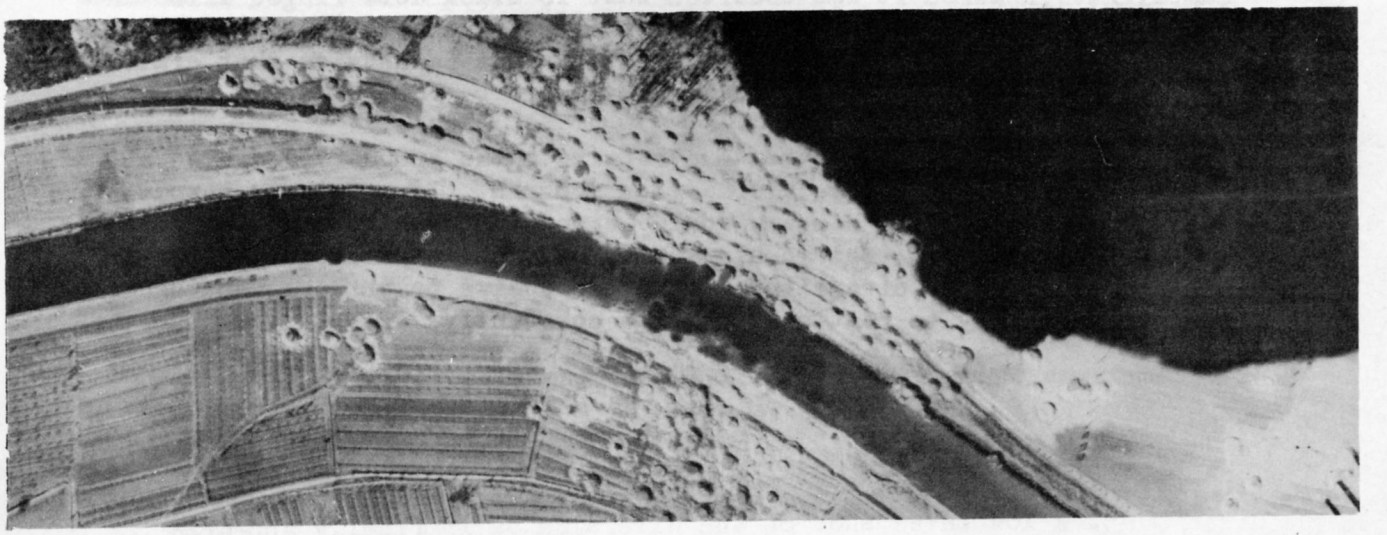
At Verona-Parona an attempt at deception was noted when the bridge was severely damaged in an attack by 15 Air Force on 28 February. On 3 March repairs were under way and it was noted three or four flat cars, two or three girders and a large railway crane were present on the south approach. The crane was assumed to be the one usually present at Peschiera marshalling yard, since cover of Peschiera revealed the crane no longer present in the yards. The bridge was made serviceable again in about six days and the crane returned to Peschiera. Two attacks on 9 and 10 March again severely damaged the bridge. On cover of 15 March the crane had again arrived from Peschiera and repairs were well under way. It was estimated the bridge would be serviceable on 18 or 19 March. On cover of 20 March however, the bridge was still impassable with the 60-foot span, second from the north end of the bridge, remaining out. By 31 March a second 60-foot span had been removed from the north end of the bridge and it was thought possible that the repairs were deliberately held up awaiting the completion of repairs six miles northwest at San Ambrogio. However, the night operational pattern was clearly evident and an additional crane had been moved in on the north approach. It was probable that each crane was used to set one span, thus shortening the time required to make the bridge operational. Night photos taken at 2150 hours on 1 April confirmed the night operational status of the bridge. The two spans were in place and the bridge was passable to single-line traffic. However, photos of 4 April showed the two spans again removed. Similar attempts at deception were noted at the Ala, Rovereto and San Michele main bridges. In some cases the enemy deliberately removed a span from a bridge to protect it from attack. For example, the Rovereto rail bridge was destroyed by B-25s on 4 April. Shortly thereafter the two north spans of the nearby Ala bridge were removed and placed near the track about 800 feet south. These methods of deception had previously been analysed by photographic interpreters as far back as December, and as each bridge was brought into the familiar pattern of deception, it resumed its position on the target list.

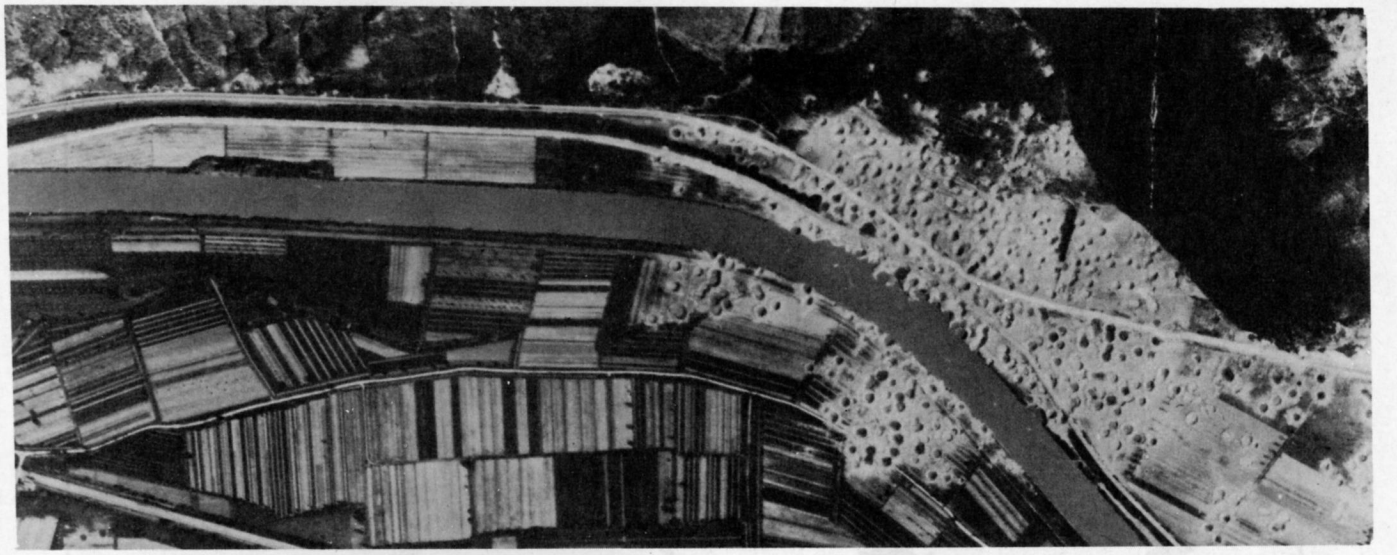
A unique type of deception appeared in the latter part of the campaign. In March it was observed that 15 black dots ringed with white were painted on the tracks at the north choke point of the Trento marshalling yard, presumably to give the impression that craters blocked the line.

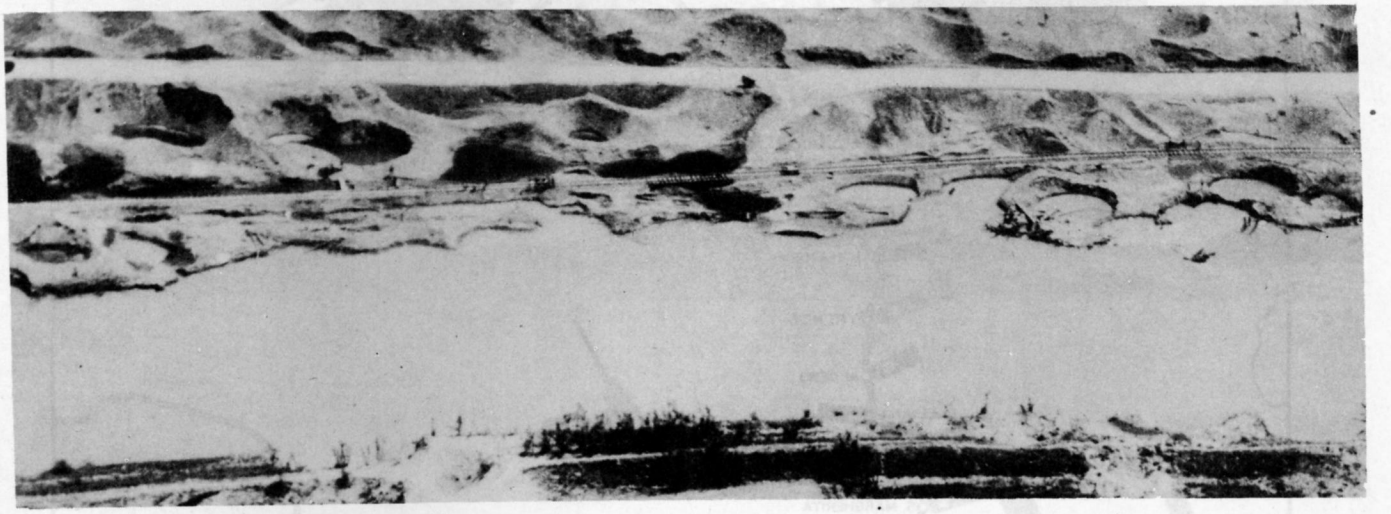
The enemy's construction and repair on the Brenner presented a serious difficulty to our interdiction program. If granted a respite for only a few days, the enemy could be counted upon to mend the cuts in the line and move through his trains of supplies and equipment; his construction of diversions and rapid repairs to bridges and tracks made it necessary to reattack the line constantly.











Repeated attacks were carried out against the San Michele diversion bridges to maintain a permanent point of interdiction. These photos illustrate several stages in the repair:

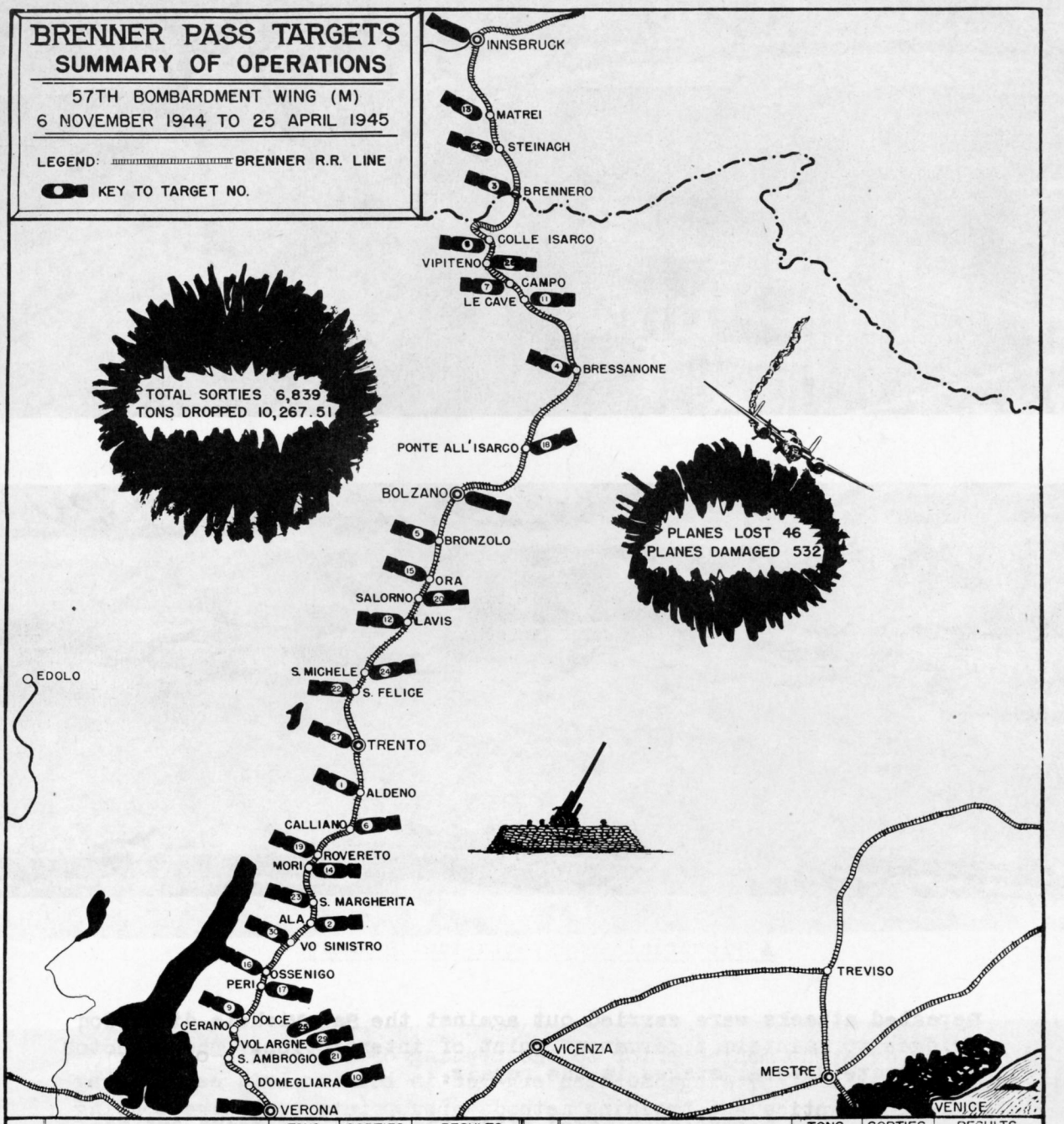
1. The diversion blocked after the first few weeks but the rail bed still in its original position.

2. After a successful attack in February the bridge and a large section of the rail bed were destroyed.

3. In rebuilding, a new rail bed was made and the 100-foot bridge replaced by a 30-foot span.

4. After a successful March attack the rail bed was moved again to a third position.

5. A low level shot of the diversion as it finally appeared after repair by Allied engineers.



NO.	TARGET	TONS DROPPED	SORTIES FLOWN	RESULTS DES.	DAM.	BLDG.	NO.	TARGET	TONS DROPPED	SORTIES FLOWN	RESULTS DES.	DAM.	BLDG.
1	ALDENO	96:00	58			3	16	OSSENIGO	254:70	153			6
2	ALA	959:86	617	7	4	10	17	PERI	52:00	27			1
3	BRENNERO	37:70	26				18	PONTE ALL'ISARCO	3:60	24			
4	BRESSANONE	116:40	159			2	19	ROVERETO	1,072:10	717	5	6	13
5	BRONZOLO	23:00	39				20	SALORNO	499:00	324	1	1	10
6	CALLIANO	629:90	503	2	5	13	21	SAN AMBROGIO	797:77	512	1	4	11
7	CAMPO	314:60	212	1	2	4	22	S. FELICE	75:00	41			3
8	COLLE ISARCO	36:00	20			2	23	S. MARGHERITA	324:42	223		2	10
9	DOLCE	171:50	103			4	24	S. MICHELE	1,394:25	823	10	7	17
10	DOMEGLIARA	71:75	36		2		25	STAZ DI CERANO	235:40	129			5
11	LE CAVE	31:00	24				26	STEINACH	286:00	208	1	3	4
12	LAVIS	933:80	730	7	1	5	27	TRENTO	201:05	124		1	1
13	MATREI	267:50	162		3	3	28	VIPITENO	139:55	86	3		
14	MORI	124:20	77			2	29	VOLARGNE	231:05	151			6
15	ORA	454:36	317	2		8	30	VO SINISTRO	371:05	214	1		8