MS # D-048

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MANUSCRIPT DATA SHEET

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II. Title : Experiences Gained in Fighting Large Fires Resulting from Air Warfare.

III. Date ordered: 25 April 1947

IV. Sources:

A. Consultants: None

B. Documents: Own occupational experiences, written from memory.

Group Special Topics

Lt. Gen. Dr. ing. M e y e r :

"Experiences infighting against conflagration fire."

Fire departement affairs before the war.

Shifting in war time.

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Experiences in Fighting Large Fires*
Resulting from Air Warfare

Before the war the German fire fighting organization was on a very high level. Numerous fire department chiefs of other European countries took their training with the German professional fire brigades. The fire-fighting equipment industry was pioneering in several fields and leading in the world market. In spite of increasing stepping-up of our economic activities and of the inevitably resultant danger of fires, actual large fires were rare. The figures for fire damage in Germany steadily decreased in the last ten years before the war.

If, in spite of this, fire damages of hitherto unknown proportions occurred during the course of the war, they were due to several factors aside from the increasing superiority of enemy air forces. First, the effective possibilities of the weapon "fire" were not recognized sufficiently and early enough by the authorities. Then, too, countermeasures were taken too late and showed considerable weaknesses. Finally, important new knowledge was gained in the course of aerial warfare.

German fire fighting, until shortly before the war, was organized exclusively to meet local requirements. There was no state supervision. Such supervision was first established by the Reich's Fire Fighting Ordinance in 1939. Up to this time technical development had been in the hands of the Reich's Society of German Fire-Fighting Engineers, which had achieved success

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* The German fire-fighting organization statistically differentiates between small, medium and large fires, according to the number of hose lines needed to fight the fire. Fires described as "large or area fires" are those which were able to spread unhindered for considerable time. They are not attacked directly but are localized first.

[1] in numerous fields in cooperation with the fire-fighting equipment industry. It lacked the ability, however, to effect, with the necessary emphasis, the standardization of the fire-fighting organization.

One of the first measures of the Reich's Air Ministry in the field of air raid defense was, therefore, to effect the standardization of vehicles and equipment to assure neighborly aid in the fighting of fires. In spite of the importance of this measure for national defense, several cities followed this directive only half-heartedly, so that during the first large fires resulting from air attack in Berlin and Leipzig, some of the units arriving to aid in the fire fighting could not be used because of differences in the hydrant connections and the diameter of the hose.

[2] Before the war, fire-fighting units consisted of:

a) the local professional fire departments (from 1939 on called the Fire Protection Police) with a total strength of approximately 12,000 men, about 180 of whom were engineers acting as senior officials,

b) a number of professional fire brigades in large industry,

c) a number of fire brigades in military installations,

d) about 2 1/2 million volunteer and conscripted firemen of the communities.

The professional fire departments were forced to fill their positions, sometimes up to 90%, with candidates for the military service. This measure meant an accumulation of highly-valuable subordinate commanders of the Wehrmacht on whom the fire departments could not count in case of mobilization. As a result there was an appreciable lack of subordinates when the necessity arose of increasing the fire-fighting units for handling large fires. Completely failing to understand the physical load on the individual at

[2] large fires, which frequently demanded continuous activity from 36 to 48 hours, the effectiveness of the professional fire departments was tremendously lowered by the assignment of totally unsuitable replacements.

In the large cities, the professional fire departments were available for organizing fire protection in air raids. They were municipal organizations which could not be "mobilized" without difficulty, but they had at their disposal:

rich experiences in fire fighting with the use of gas protection equipment,

their own widely ramified communications net,

their own commanders and subordinate commanders who had a good knowledge of local conditions and of dangers, especially in industrial areas, as a result of their fire police duties,

experience in giving aid of all kinds,

in many instances, their own medical sections, etc.

The professional fire department, therefore, was the logical organization to take over air raid defense since it had taken a practical part in all of its branches in peacetime, and in wartime would have found merely increased duties. Instead of increasing the size of the professional fire departments appropriately at the outbreak of war, they were attached to the regular police force as a special branch, "Fire Protection Police." Its engineers were made police officers. However, simultaneously with the activation of the air raid defense organization, the professional fire departments were "dissolved" and made part of the Security and Auxiliary Service, which on its part set up new fire-fighting and decontamination units for fighting fires.

[2] The command staffs consisted solely of officers of the municipal police force, whose duties in the elimination of emergencies arising in connection with peacetime air raid drills would have consisted solely in blocking off the area.

The fatal weaknesses of this organization showed themselves as early as during the first major drills. Still, it was not until the year 1943 that changes were considered which, however, were not put into effect, since aerial warfare had already taken on a severity which excluded any measures of such far-reaching importance.

[3] In case of large fires, mutual assistance by the air raid defense centers had been provided for. The increasing air superiority of the enemy, characterized by simultaneous attacks on several targets as well as by constant aerial danger, not only precluded extension of fire fighting aid to neighboring communities, but emphatically demanded additional fire-fighting forces over and above those actually present. For air raid defense centers of the first order, such forces were activated by the Reichs Air Ministry in the form of motorized battalions of the air raid protection auxiliary services, the later air raid protection regiments. For the remaining territory of the Reich, the Office of the Constabulary, Ministry of the Interior, formed fire protection police regiments (of 3 battalions with 3 to 4 companies each) from detachments furnished by the medium- and small-sized cities. The Reichs Air Ministry retained the regimental strength. The staffs of the fire-protection police regiments were soon dissolved since this unit showed itself to be too unwieldy in use. All now independent battalions were placed under a special staff for purely administrative

purposes. Regiments and battalions were subordinate to Luftwaffe administrative areas and the higher SS and police officials, and were used by these officers on request. They proved their worth. With the beginning of absolute air control by the enemy, however, they frequently suffered severely from enemy action and reached the destinations to which they had been ordered either too late or not at all.

In peacetime, the vehicles of the professional fire departments were designed according to the following principle: First, saving of human lives, then reduction of damage. Even at large fires this principle held. However, since people do not stay in their living quarters during air raids, but in cellars, ladder trucks in a normal train of apparatus became an unnecessary burden. It is sufficient, therefore, if the battalion has some ladders at its disposal for special occasions. The ladder can be used as a "water tower." It has been proved, however, that due to debris on the streets after air raids, the possibility of bringing the unwieldy vehicle to the desired place exists in only a few cases. Besides, the vehicles of American fire departments, which according to reports in trade journals often work with water towers, prove that these can be constructed along technically simpler lines. (Telescopic or extension standpipes.)

Even in peacetime, only a fraction of the efficiency of the pump was used to throw the water from the jet pipe onto the fire. A large part is lost through the friction of the water along the inner walls of the hose. The loss by friction in unfinished [not rubberized] hemp hose is approximately twice that in hose rubberized on the inside; it increases approximately as the square of the quantity of water. At large fires in aerial warfare it

[3] is often necessary to bring the water over long distances. It is therefore advisable to choose hose that is rubberized on the inside with the largest possible diameter. When standardization was adopted, hose diameters of 75 mm. (B) and 52 mm. (C) were chosen in consideration of the allocated quantity of the material available. Since weaving mills were allotted hardly any rubber in the last years of the war, the fire departments depended almost exclusively on hemp hose.

[4] With a maximum constant pressure at the pump of 10-12 atmospheres, a power pump had to be installed every 300-400 m on long distances when two parallel B-type hose lines were used. In this way nearly 50% of the power pumps in large fires could not be used for actually fighting the fire, because they were needed to bring on the water. A technical improvement might possibly have been to increase the pump pressure to about 20 atmospheres, or to increase the diameter of the B-type hose lines to about 100 mm. Neither of these solutions could be carried out under the conditions existing at that time.

All vehicles had normal chassis and had too little ground clearance. It is therefore advisable to select vehicles capable of cross-country operations. These measured up well in tests.

In addition to the two standardized power pumps of 1500 liters per minute and 2500 liters per minute on 3-ton and 5-ton chassis, respectively, the units carried portable pumps of 800 liters/minute, in case the heavy vehicles could not reach the water source because of terrain difficulties. Fire boats proved very effective in the port cities; they have a water

[4] capacity of 6 - 12,000 liters/minute. Since waterways are less sensitive to bomb hits and even collapsed bridge arches usually permit some passage, it was only in exceptional cases that fireboats were unable to reach the place where they were to be employed.

A special auxiliary apparatus, rarely needed in peacetime, is the "hose bridge." It proved indispensable in aerial warfare at the larger fires in order to prevent hose lines from being damaged or torn when driven over.

Gas protection equipment was needed in only few cases at industrial fires. On the other hand, the eyes were attacked at large fires by hot dust in a manner formerly unknown. Some units after operating 24 hours continuously had losses up to 70%, lasting 3 - 5 days. The equipment was therefore supplemented by glasses, the frames of which were made out of a suitable cool material; rubber proved of no value here.

In regard to fire protection, four stages of development were noted in the course of the war in the air;

1) Superiority of the German Luftwaffe - peacetime missions of the fire departments,
2) Equality of the air forces - small fire damages, no large fires,
3) Superiority of the enemy air force - occasional large fires which could be handled successfully by timely employment of the fire-fighting forces,
4) Complete control of the air by the enemy - numerous large fires, which spread unhindered as soon as the enemy holds down the local forces by attacking in waves and makes it impossible to apply fire

[4] fighting aid by strafing the roads of approach.

[5] In view of the above-mentioned development, peacetime fire-fighting tactics underwent fundamental changes. In peacetime, a train of equipment left within 40 to 60 seconds after receipt of the fire alarm, fought the fire by attacking it at the core as much as possible, using care to avoid any damage by water, and extinguished the center of the fire so thoroughly that a second outbreak was impossible. With the organization of the air-raid protection system, the possibility was taken into consideration at the start that the number of fires reported might exceed the available fire-fighting units. The fires would then have to be fought according to their importance, some sites might even have to be abandoned. This necessity arose in increasing measure with the mounting intensity of the air raids. As a result large buildings or even entire blocks, which from a technical fire-fighting standpoint could have been saved without difficulty, had to be neglected, because the forces available were needed more urgently elsewhere. It is important that the public be fully informed of these measures. Otherwise they would not understand, for example, why a train of equipment, reserved for use only at the site of a large fire, should stand by, awaiting orders, and could not attack a fire blazing in the immediate vicinity.

In the successful fighting of fires the "period of alarm" or "period of commitment" is of special importance. It comprises the following factors: distance to the call box, transmittal of the report, arousing of the watch, the run to the scene of the fire, laying, and getting water - all of which in peacetime amounts to a maximum of 15 minutes. In large fires in aerial warfare, this time, even if considerably longer, is equally important.

[5] Within this period, which can last for hours, minutes are decisive, if it if vital whether a fire-fighting unit ordered to an especially endangered point arrives there in time or not. In air raid protection the length of this period depends mainly on the following:

a) Report of the fire and inquiries,

b) Estimate of situation, decision,

c) Transmission of orders to the units for their employment,

d) The run and going into positions.

The question whether air raid protection forces should stay at a dangerous post during the raid, and whether fire-fighting units should leave prior to the end of aerial danger, has been discussed frequently and not decided the same way at all times. On the one hand, it has been objected that neither personnel nor materiel replacements for fire fighting forces of such high value are available; on the other hand it was proved that losses of time resulting from everybody staying in the shelters until the "all clear" was sounded were intolerable.

[6] Just as the fighting troops, so must the air raid protection service leave its observers and reconnaissance personnel at their posts during an attack. In this way they can at once detect fires that are started and transmit their observations during a lull in the attack. Fire fighting units, too, must move out when the situation demands, even if losses are sustained.

The fire alarm data and the results of reconnaissance cease to correspond to actual conditions if they are evaluated in the command post, since the fire makes constant headway. On the other hand, when there is danger of large

[6] fires, the order to attack the fire must be given, if possible, before the individual fires have united into an area fire. This presupposes that the responsible director of the fire fighting of an entire air raid protection center is, without question, a fire department expert. He must also have sufficient knowledge of the locality and its potential dangers, to be in a position to judge the probable spread of the fire during the time needed to go into action against it. A change of high fire department commanders who are familiar with local conditions must, therefore, not be made. For the same reason, while a fire is being attacked, the command should not pass to a higher ranking commander, not acquainted with the locality, who happens to arrive at the scene.

Quick and sure transmittal of orders directing fire-fighting units to the scene of a fire is only possible by radio. This is especially true for those units which are located outside the air raid protection center or which have already been moved to stand-by points. With the advent of area bombing, all telephone connections were, as a rule, immediately put out of operation. Messengers were wounded or crashed with their vehicles. Unit commanders, after a long wait and on the assumption that the command post was knocked out, went ahead according to their own judgment.

It is important that the stand-by points be staffed sufficiently with personnel familiar with the locality, and that this personnel reconnoiter the approaches to the fire before the departure of the units. Such action is necessary because the turning around of a motorized column in the ruined streets is very time-wasting, if not impossible.

Regiments and battalions were generally not located in the air-raid

[6] protection centers themselves. Especially where they were made available for the protection of rather large areas, they were stationed in the country. Distance to the fire was of no concern since, as a rule, the equipment was moved to the vicinity of the localities where an attack was expected by reason of the air situation reports.

At large fires, or when danger already existed that several fires would unite to form an area fire, the units were not directed to specific points but the endangered area was surrounded. Every unit received a certain sector with the mission of holding the line and keeping liaison with the flanks at all costs. If the situation permitted, the units were to save single objects within their assigned sectors.

The encircling ring, in consideration of the probable spread of fire, must be selected so that the units can actually take the positions ordered. The retreat of a unit once committed in an attack against a fire nearly always results in the loss of the entire hose equipment. In such cases the units were practically eliminated by this loss.

[7] When forces strange to a locality are employed, it has proved advisable to divide city maps by means of a grid system and to direct units to specific grid squares, since street signs are often destroyed and street names are illegible on pocket-size maps.

According to each individual situation, the encirclement is slowly closed by a simultaneous advance, or the entire burning area is pushed back. In general it is advisable to proceed slowly and to let lost places burn out.

[7] The area lying inside the encirclement must be considered completely lost by the command. Simultaneously with the decision to abandon the area in question, the order has to be given for the evacuation of the persons still in air-raid shelters there, and for the withdrawal of fire-fighting units still operating in the area. In special cases, fire-fighting forces may be permitted to remain within the encircled area for the protection of especially important buildings, provided a route of withdrawal is assured. It happened frequently that units were cut off by the fire and were lost.

Experience at large fires has taught that human beings in shelters are physically and mentally so depressed during the course of a heavy attack, that they do not flee from the fire in time. In constrast to the panic that normally breaks out under similar conditions, people were usually completely apathetic. It was difficult to induce them to leave the shelter. This phenomenon is traced to the increasing lack of oxygen. Even air-raid bunkers within a center of conflagration offer no security. Aside from the heating of the masses of concrete, the fresh air sucked in by the ventilators becomes steadily warmer and poorer in oxygen. Unless especially favorable conditions exist, e.g., location in a park or a fairly large open area, it is advisable to clear even bomb-proof bunkers as soon as the danger exists that the surrounding area will be afire.

If people are cut off by fire, they have to be brought out under protection of water. For such cases the plan was to form "water-lanes." A curtain of water was pushed down the street by posting hosemen every 50 m. These hosemen douse each other with water, and reduce the heat and rain of sparks to such an extent that the people can be passed down the lane.

[7] Individuals as well as small groups have repeatedly been moved out of burning buildings under protection of water. Whether, however, water-lanes were actually used extensively in the last phase of the war is not known. It is open to doubt, however, whether in view of the comparatively unwieldy organization within a large area of fire, the necessary power pumps could be brought up quickly enough. Every possible means therefore must be employed to get people into safety early, if there is danger of a conflagration. Special actions such as the formation of water-lanes always are a detriment to the actual work of fighting the fire. If such a situation arises during a large conflagration, it may permit the fire to get out of hand and thereby cause a catastrophe.

[8] The problem of water supply caused considerable difficulties in many cases, especially as demands increased during the course of the war. The problem was never solved completely in a satisfactory manner. Since peacetime installations were sufficient in the first two years of the war, supplemental measures were taken too late or were never pushed with sufficient energy. Moreover, the shortage of cement and iron was already becoming noticeable at this time.

These difficulties frequently led to a discussion of the question why the fire department still extinguished with water. Chemical extinguishing agents and methods exist which act better and faster, such as foam, carbon tetrachloride, solidified carbonic acid, etc. Their field of application is very limited, however. Fundamental objections exist against the use of flame-extinguishing gases because of the danger to the population.

Attempts have been made to extinguish fire by demolition. The explosion

[8] was to cause the buildings to collapse. Wooden construction and iron beams, however, prevented complete collapse in most cases, so that the desired effect did not come about. The possibility of "blowing out" the fire with the aid of air pressure from bombs was also discussed. Tests were not made, however, on the assumption that the necessary pressure would also cause undesirable destruction in the vicinity.

Air foam - in its real sense not a special extinguishing agent but rather water which is held in finely divided form by the small foam bubbles - may possibly be able to supplant plain water some day and thereby decrease the demand for water to a mere percentage of present requirements. In its present form and application, however, it lacks effectiveness in depth since it cannot be thrown as a stream under pressure. The mass of foam flutters like snow flakes and is torn away by the gases of the fire. Its application, therefore, is limited, for the present, to extinguishing burning liquids.

In peacetime an adequate supply of water for fire fighting in the German cities was usually assured by high-pressure water lines. Only in the peripheral areas and for industrial plants situated away from the cities were additional supplies of water necessary. In the first stages of aerial warfare fires were fought almost exclusively by tapping the water mains. The failure of single pipelines is of no consequence when the system is appropriately laid out with belt lines and several separate feed mains.

The water main drops out of the picture for fire-fighting purposes as soon as the enemy air force is in a position to attack in masses. The

[8] creation of a water supply for fire fighting independent of the water main is possible by installing surface or subterranean water tanks or by using streams, ponds, etc.

[9] A medium-sized power pump feeds about 2 B-type hose lines, which at 4 atmospheres of pressure at the nozzle will throw about 1,000 liters per minute with a 20-mm nozzle. Used for 24 hours continuously, which is not unusual in large fires, this amounts to a water demand of 1,500 cbm for one power pump. It follows from this, that within municipal building areas it is hardly possible to assure the necessary amounts of water in artifically constructed collecting tanks (water pools). It has furthermore been shown that due to seepage, evaporation, ice formation, and damage to the banks by bomb hits, actually only a fraction of the calculated amount of water is available.

A really adequate water supply can only be attained by the exploitation of running and standing waters, provided that terrain conditions permit bringing the water to the air-defense center. A system of canals or large pipes leading from the waterways is an even better solution. It should be noted here that at suction heights of more than 4 m, the efficiency of the pumps decreases considerably.

Experience has taught that installations for fighting fires alone are not sufficient. The fire-fighting organization must be supplemented by "preventive fire protection" which consists of measures for the prevention of fires and their limitation. By fire limitation is understood the division of large buildings, groups of buildings, plants, warehouses, or built-over

[9] areas into "fire sectors" by precautionary structures or breaks (open spaces). These serve to prevent the unhindered spread of the fire; they are bordered by fire walls, fire-proof ceilings, streets, breaks, or waterways, under the protection of which the fire department begins its attack. The objective of a fire-fighting attack is to localize the fire at least to the fire sector concerned. On the other hand, it must be admitted that anything of value within the fire sector is lost. It follows from this that the smaller the sectors, the less are the dangers and losses. In actual practice the wishes of the fire department here oppose the economic structure and have to be balanced with it.

These observations apply equally well to air-raid protection. As a rule the smallest fire sector is a block of houses, bordered by streets. If the fire jumps from one block to another, the danger of a large conflagration is present. The fire department will be aided in localizing the fire to the sector concerned if the breaks (clear spaces) bordering it are wide, if the flames find little to feed on in the interior of the block, and lastly, if the job of fighting the fire is not hindered by construction in the courtyards. In estimating the situation it must also be noted that a collapse toward the street must be expected after the building has burned for some time. According to experience, the rubble covers the street to a depth of 1/2 to 2/3 the height of the building.

[10] From this it may be deduced that in old city areas and in cities which have kept their medieval character to a great extent, the danger of large fires is very prominent. Responsible fire chiefs with a thorough knowledge of locality and dangers are needed to make the hard decision to abandon an

[10] area of some size correctly and in time.

The old Hanseatic city of Lübeck is a typical example of a city which has to count on the possibilities of large fires. This was true in peacetime as well as under conditions of aerial warfare. Because of this fact, Lübeck had the largest professional fire department in Germany in proportion to the number of its inhabitants. The heart of the old city is situated on an egg-shaped island of about 1200-m maximum length and 800-m maximum width. The western half still shows all of its medieval character marked by narrow, high-gabled houses, irregularly laid out courtyards, long building blocks, and narrow angular streets and alleys. The eastern half, already frequently afflicted with serious fires, shows a certain loosening in the street network and considerably lesser height of construction.

The western half of the heart of the city was almost totally destroyed by fire in the first large air raid, although the enemy, aside from a few high explosive bombs, dropped stick-type incendiary bombs almost exclusively. In those days incendiary bombs were considered relatively harmless incendiary agents. Regular hunts were conducted in other cities to earn the reward offered for rendering them harmless.

In the densely built-up court yards and the many-storied warehouses of the old Hanseatic city, the fire guards noticed the hits too late or were unable to get soon enough to the numerous seats of the fire. The developing fires found plenty to feed on in the masses of wood in the old roof trusses, dried out by the centuries. After a short time, the entire western part of the city was clothed in smoke and flames. Certain deficiencies became obvious in this first large area fire. For example,

[10] the fire-fighting aid came too late. Under the conditions of construction described above, it is doubtful, however, whether it would have been technically possible to prevent the individual fires from becoming a large area fire, after a mass release of incendiary bombs.

A similar danger exists when highly inflammable material is stored within apartment blocks, industrial installations, or warehouses. The residential areas of Berlin, for example, are interspersed with medium- and small-sized industries in the northern and eastern sectors of the city, where fires set difficult tasks for the fire departments. In general, however, even in these cases the fires were restricted to a fire sector since Berlin has wide streets throughout and since the houses of these sectors of the city are built solidly with low, flat roofs.

[11] It can be seen from the foregoing observations how important open spaces of all types are within municipal built-up areas. Such construction aids the rescue of the inhabitants as well as the fighting of the fire. Under the slogans "Reclamation of the Cities" and "Clearing the Courtyards of Trash," it was attempted even during peacetime for hygenic and technical reasons concerning the fire and police departments, to open up those parts of the cities that were especially endangered and to create clear spaces. The attempts, however, met with no success. On the other hand, cities must attempt at least to retain the existing open spaces. In spite of warning by experts of the fire department, the city of Kassel had constructed two-storied wooden barracks all over the palace square. After a heavy raid, the square consequently became a sea of fire. Instead of serving as a temporary place of refuge for the threatened inhabitants and as a

[11] starting point for fire-fighting and rescue activities, it hastened the catastrophe on that day and considerably increased its awful effects.

In the first years of the war, German industry had hardly any losses from large fires due to air raids. On the one hand adequate compartmentation and proper architectural layout dividing the area into fire sectors either existed or was carried out. On the other hand, the stick-type incendiary bomb is harmless against a well-organized system for protection of plants against air raids, unless the plants are especially sensitive to fire. Damages of any considerable proportions only occurred when high-explosive and incendiary bombs were dropped simultaneously and in great quantities. Destruction, however, was mainly the result of high-explosive bombs, often without fires of any consequence. Only in the wood-working and chemical industries, in petroleum plants, and storage tank areas did fire damages exceed damages caused by high-explosive bombs.

In 1912, in Lübeck, one of the largest woodyard fires destroyed a number of wood storage piles extending in series for about 1800 m. This was the only industrial fire within the last fifty years in Germany, which was able to develop to a large fire in the sense of this discussion. All attempts to extinguish the fire were in vain. The fire could not be extinguished until the last pile of wood was destroyed. The radiating heat of a burning mass of wood is so great that even lanes 100 m wide offer no protection against the spread of the fire. This experience caused all woodyards of any size to be compartmented into secure fire sectors by the construction of fire walls 10-12 m high every 200 to 300 m. This measure proved valuable also during the war.

[12] The above-mentioned experiences with woodyard fires prove what danger the tremendous and completely dried-out masses of wood existing in old buildings constitute. Cities or sectors thereof which have retained their medieval character in this regard are comparable to extensive woodyards as fire-fighting technique is concerned. In case of fire, a total loss is certain to occur unless fire sectors that will meet the test are created by decisive measures. Since fires in cities spread mainly from wooden attic to wooden attic, the city of Budapest is said to have directed that no inflammable materials may be used for the construction of staircases and attics. If such a measure is carried out, the danger of a large fire, even in aerial warfare, is considerably decreased in purely residential districts.

There were no fires of any considerable size in petroleum plants and storage tank areas in Germany during peacetime. The value of protective installations and fire-fighting methods was therefore tried out only experimentally. Experience gained during the course of the war taught that sensitive deficiencies exist in petroleum plants in spite of the usually adequate constructional compartmentation, and that attempts to extinguish burning tanks always were based on false pretenses.

The vulnerability of petroleum plants lies in the open pipe lines which traverse the entire plant. They connect nearly all groups of buildings with each other and thereby render ineffective the safety achieved by constructional dispersion. To destroy a petroleum plant, one igniting hit in a tank is usually sufficient. The contents run out aflame, reach the pipe lines, and thus spread the fire in a short time throughout the entire plant. German plants were, therefore, ordered to block the pipe ditches every 50 m by a sand embankment one meter wide.

[12] Fire-fighting tests on burning oil tanks were frequently conducted in the port of Hamburg, where a large tank and 20,000 to 30,000 liters of benzol were available for each test. After letting the fire burn for about 10 minutes, the flaming area was covered with foam while the outer walls of the tank were cooled at the same time. In most cases it was possible to
[13] extinguish the fire, but not always. Any failure was laid to too light a foam cover and to insufficient cooling of the tank walls.

Numerous fires in storage tank areas during the war showed that these tests were made under conditions which rarely corresponded to reality. It happened only rarely that the tank cover was torn off, as had been assumed in the tests. Even in these few cases the tear was not smooth. Parts of the cover or of the side wall reached into the interior of the tank and dipped into the fluid. Under such conditions any fire-fighting attempt was useless since it is impossible to cool these glowing pieces of iron sufficiently. Foam has no chance of success except when the level of the fluid has sunk so low that the parts concerned no longer reach into it and unless the sidewalls are adequately cooled at the same time.

If, due to some cause or other, the cover tears off, the stationary foam lines and pouring pipes are damaged. Therefore it is useless to set them near the cover. The foam must be poured directly on the level of the fluid. Probably the failure of some of the Hamburg tests must be laid to the fact that the level of the fluid sunk in the course of the test and that the distance from the foam pipe to the level of the fluid became too great.

During the war, the fire departments were faced with the difficult

[13] problem of bringing the foam into the fluid without too great a fall when the cover was torn off. An attempt was made to lengthen the foam line with an asbestos hose which was to reach the level of the liquid, the foam pipe being pushed over the upper edge of the tank with the aid of extension ladders and later with special foam poles. The results were unsatisfactory. In the last phase of the war an experiment was to be made to cut the tank close to the level of the fluid with cutting torches in order to pass a pouring pipe through the opening. These tests, however, did not reach the execution stage.

[14] In most cases, fires in storage tank areas arose from the fact that the containers were damaged so that the contents ran out aflame, filled the pit, and threatened the neighboring tanks by heat radiation. These fires were always extinguished, usually within a short time. Here, too, it is important that the fire sectors be properly selected. The pit created by erecting a wall around the individual tanks must be of such dimensions that the escaping liquid will not run over, even in the most unfavorable cases. Furthermore, neighboring tanks must be placed sufficiently distant and must be provided with a sprinkler system. In general, that distance is sufficient which results when each tank has its own surrounding wall, that is, when each tank is a fire sector.

The task becomes difficult when the tank is torn open so far that the leak cannot be stopped. In an attempt in one case of that sort to pour foam through a side opening of about 2 sq.m. into the interior, a tremendous explosion occurred, hurling the lid several hundred yards and causing a sky-high pillar of fire. Since enclosed areas during a fire

[14] generally are so rich in gas as to exceed the point of explosion, the phenomenon can only be explained by the fact that the little water present in the foam not only vaporized immediately but also broke down at once so that the oxygen necessary for the explosion was released. Foam may therefore not be used if the burning liquid is still more or less within an enclosed area. In borderline cases the tank must be constantly cooled both before and during the foam attack.

A phenomenon so far unknown in city fires is the "fire wind." It was first observed in Lübeck. Firemen reported that they had to hold onto the hose lines in order not to be hurled into the fire by the force of the wind or suction. These reports were later verified by similar observations in Leipzig where the fire wind was so strong that vehicles were overturned, power pumps on runners were set into motion, and people hurled to the ground so violently that they suffered severe injuries. It is not known whether fire winds with equal effects were observed in the larger fires

[15] during the last months of war. Science has not yet given an unequivocal explanation; it may be that a comparison with the enormous prairie and forest fires of America will bring us closer to a solution.

As early as the fall of 1939, an Englishman asserted that fire would be a dangerous weapon in this war. The course of the war proved this prediction in a manner reminiscent to the city fires of the early middle ages.

The science of fire fighting will progress. Problems of construction of apparatus, of extinguishing agents and methods, which were raised during the large fires, will be solved. That principle of fire-fighting

[15] tactic, however, will always stand fast which says that extensive damages from fire cannot be prevented by fire-fighting measures alone, but always have to be supplemented by installations and measures for the prevention and localization of fires. This means that as long as human living- and working-quarters are exposed to fire by airplane action, the success of the fire fighting will always depend on the ratio of power in the air.

Absolute control of the air assures the use of the weapon of "fire" without any resistance.

[signed:] Dr. Meyer