



INDUSTRIAL CAMOUFLAGE MANUAL

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INDUSTRIAL CAMOUFLAGE MANUAL

Prepared for the Industrial Camouflage Program
at Pratt Institute, Brooklyn, New York

by

KONRAD F. WITTMANN, A.I.A.

in collaboration with the faculty

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DEDICATION

This Manual is dedicated to Colonel Homer Saint-Gaudens, soldier, gentleman, author, art critic, and friend. A leading figure in the development of camouflage in the first World War, who never allowed his interest to flag during the many years of peace, he is again a camouflage leader in the present world conflict. But for his sympathetic understanding and cooperative encouragement these findings could never have materialized into this publication.

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INTRODUCTION

This Industrial Camouflage Manual represents many of the experiments and experiences that have developed in the classrooms and camouflage laboratory at Pratt Institute since the inception of the program in September, 1940. The material was originally intended for student use but soon embraced problems in the entire field of Industrial Camouflage.

Because of the enthusiastic and widespread interest that early developed from many sources, especially other educational institutions, it was decided to gather the more significant findings into a publication that could be shared by all. It should be borne in mind that this Manual is not a book in the definitive sense of the word but rather a report of the activities to date of interested personnel at Pratt Institute to contribute to the all-too-meager study of this fast developing new area of war effort.

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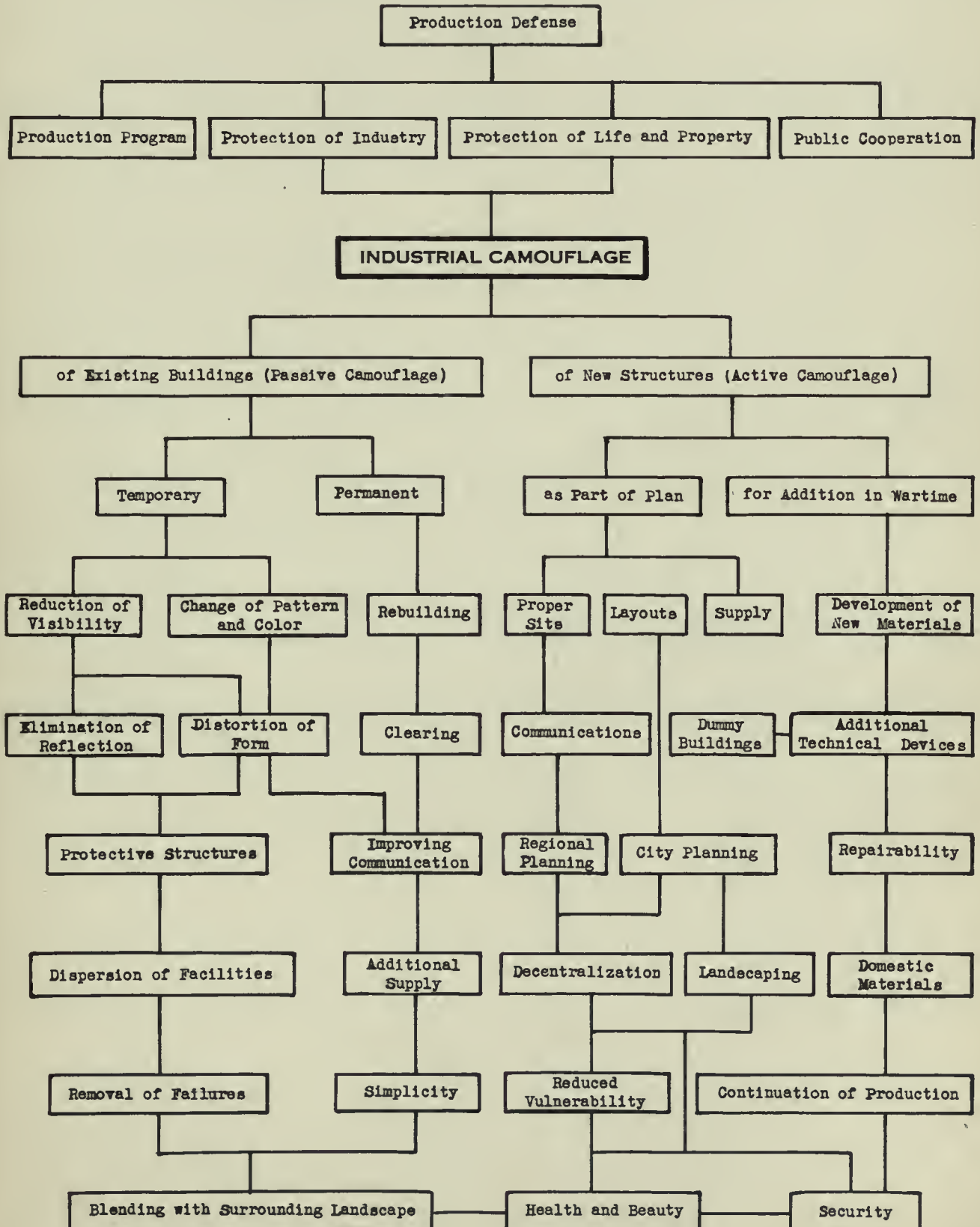
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SCOPE OF INDUSTRIAL CAMOUFLAGE



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PART I - NEW ASPECTS, NEW REQUIREMENTS, NEW PROGRAMS



Every aerial view reveals the story of the origin and growth of the American town. Cities were planned as two-dimensional design - a layout of streets, highways, sidewalks, gas mains, water mains, and sewers, cutting straight lines into the virgin face of the landscape. Sometimes the gridiron of streets was groping along the low ground of valleys only, sometimes it covered plains and hills as a continuous pattern. Railroads and railroad sidings came later; docks, bridges, and factories dotted the rural countryside with far-visible landmarks.

This gay and revealing picture assumes new meaning under the threat of aerial warfare. We study possible lines of approach along rivers which cannot be "blackened out" - along highways and railroads. We check the vulnerability of bridges; we discover the dangerous neighborhood of target areas and landmarks. A new element determines our planning - the bird's-eye view. Until now, we designed a factory with ground-plan and elevation, but it is no longer unimportant how this looks from the sky.

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VISIBILITY OF LANDMARKS

Seen from greater height
(as this picture, which
was taken at an altitude
of more than 12,000 ft.)
reflections are more ob-
vious than shadows.

Highways, city streets,
and water surfaces are
seen, even through hazy
atmosphere. Therefore,
the covering of reflec-
tive surfaces, which may
be used as landmarks, be-
comes imperative.



Seen from somewhat lower (this picture was taken at an alti-
tude of 10,000 ft.), the pattern has more detail. Shadows
begin to count. White buildings are very visible if they
have long lines; other colors are not very distinct. The
pattern is more one of light and shadow, than of colors.
Minor differences in elevation are hardly noticeable unless
stereo-pictures are taken.

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PROMINENCE OF LINES AND SHADOWS



This picture demonstrates the conspicuousness of diagonal lines within the immense pattern of city blocks. The flier takes such lines for his orientation. Main arteries, which cut across the vast rectangular pattern, like Fairmount Park in Philadelphia, provide an excellent guide for the airplane.

Shadow is most conspicuous on vertical views, indicating the height of buildings and outlining their architecture. The high tower in the center of this photograph casts its shadow almost across the whole block. Flat roofs are more or less dark, pitched roofs have sharp reflections. Coloration is not very important, nor would any pattern, painted on a roof conceal the building as long as the shadow remains. The ornamental layout of walks around the State House is very obvious.



Super-highways, slashed through the landscape in straight lines are the natural lines to follow with the plane. Target areas, lined up along these highways are easily recognized, the distance for bomb release is easily measured. Straight lines in the landscape help the aviator.

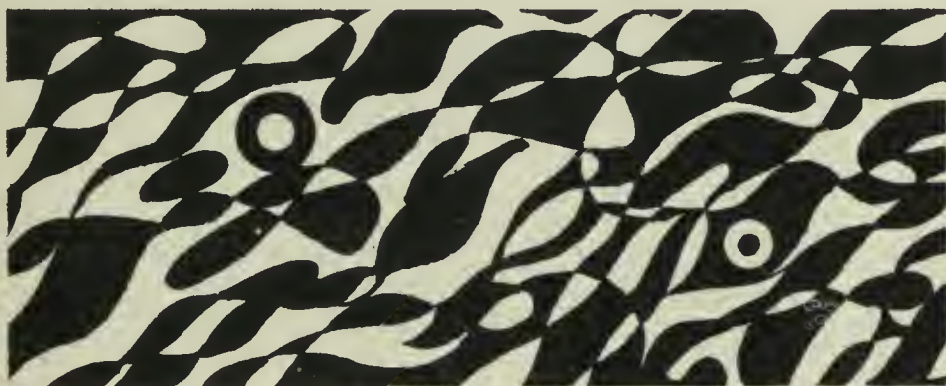


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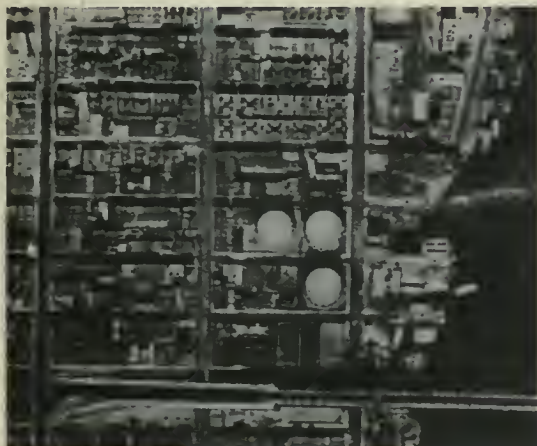
CONSPICUOUSNESS OF ROUND FORMS



A circular form within any figuration of round or straight forms attracts immediate attention. Circular lines or circular shadows have an inherent conspicuousness even if relatively small.

This explains the conspicuousness of the eye, both of men and of animals. Gloss and roundness make the eye striking and the most characteristic feature of any face. Nature has invented many ways to protect, conceal, and duplicate this precious instrument.

Gas holders and other round structures, like a stadium, a traffic circle, or the cupola of a church, are very obvious in an aerial view. Such forms are used by fliers as landmarks for orientation.



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CONSPICUOUSNESS OF STRAIGHT LINES AND REGULAR FORMS



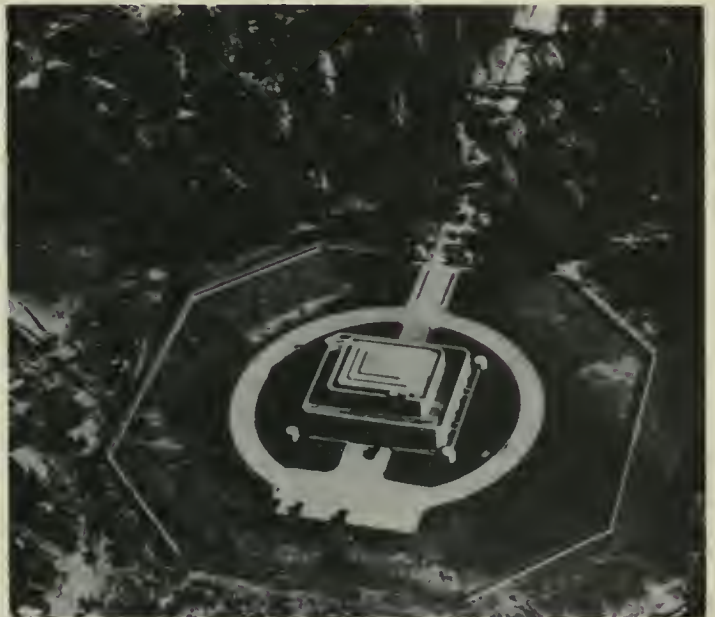
The eye is very sensitive in spotting regular forms among many irregular ones. At the first glance, we see the two regular squares. Similarly, looking down at the houses and streets of a city, we pick out first the regular shapes.



Straight lines or any combination of straight lines, such as parallel or angular lines, stand out obviously within an irregular pattern.

A perfect example of everything that makes a good target:

Straight lines, circular forms, simple geometrical shapes, avoidance of trees, white buildings of definite form, contrasting with dark surroundings, and finally a straight, four-lane highway as a dead-end approach; very suitable for getting the target into the finder at a long distance.

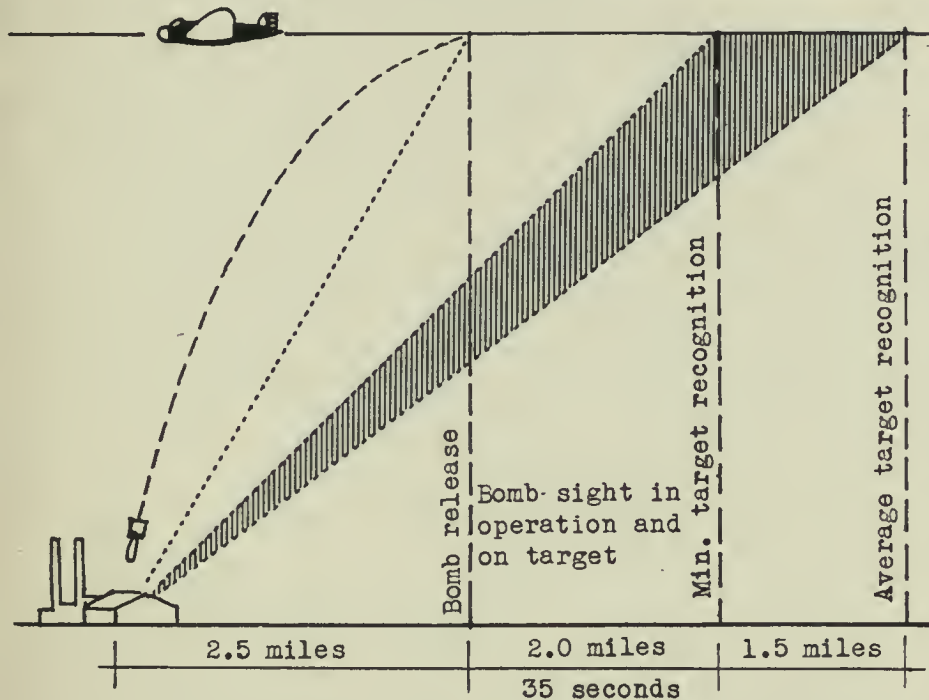


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DATA ON BOMBARDMENT



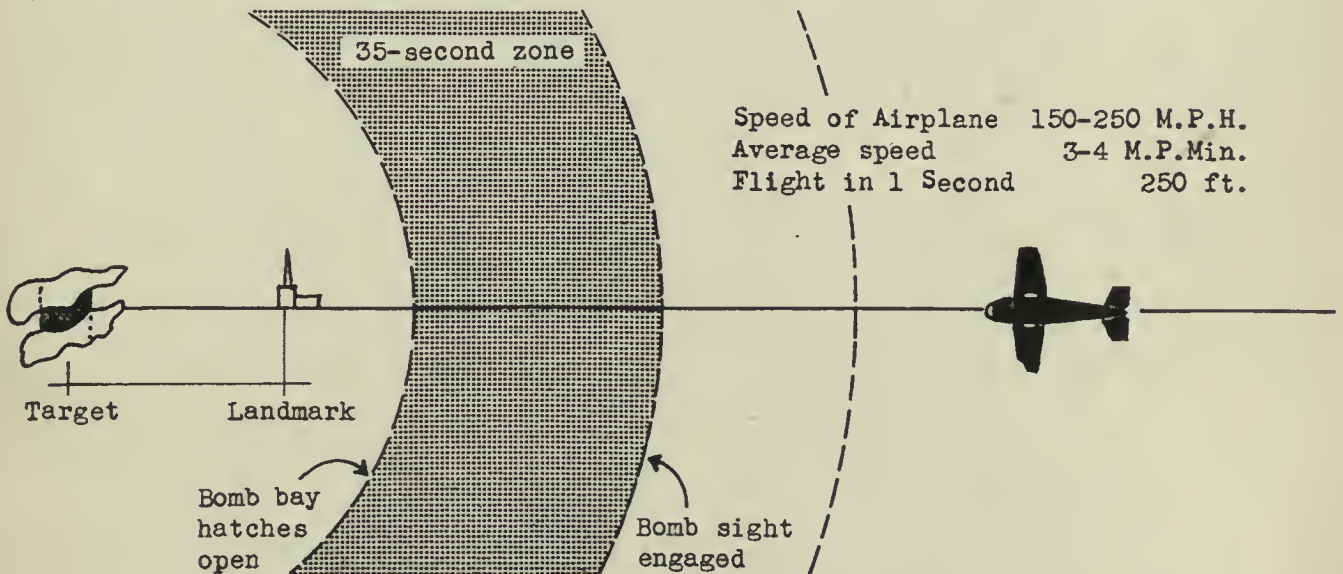
Figures are averages for graphic representation:

Average target recog....6 mi.
Angle of average target recognition..... 35°
Minimum target recog... $4\frac{1}{2}$ mi.
Angle of minimum target recognition..... 45°
Time for bomb-sight operation.....35 sec.
Time between av. and min. tar. recog.....25 sec.
Distance of bomb release..... $2\frac{1}{2}$ mi.
Angle of bomb release..... 60°

Altitudes for bombing

Low2000-5000 ft
Medium low. . .5000-9000 ft
Medium. . . .9000-13500 ft
High.13500-18000 ft
Maximum. . . above 18000 ft
Recent tactics in daylight bombing. . . 18000-25000 ft

The critical time for operating bomb sight for precision bombing is 35 seconds before bomb release line. The bombardier must spot the target well before (5 or 6 miles). For a target under 250 ft. in length 1 sec. is decisive.



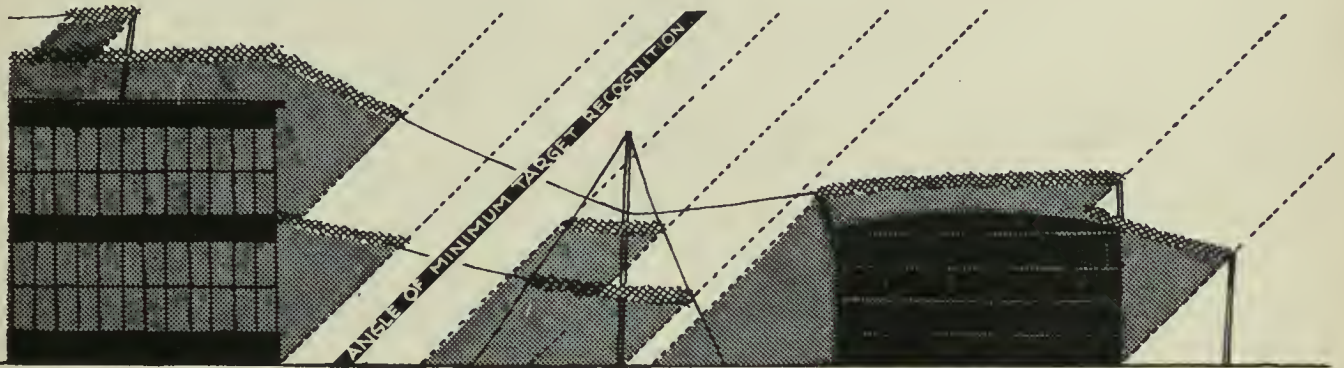
If the target is well concealed, landmarks on route of flight may be used for aiming, provided their distance from target is known, and landmarks are within critical bomb-release zone. Landmarks at greater distance (10 mi) are helpful in checking course and preparing for action.

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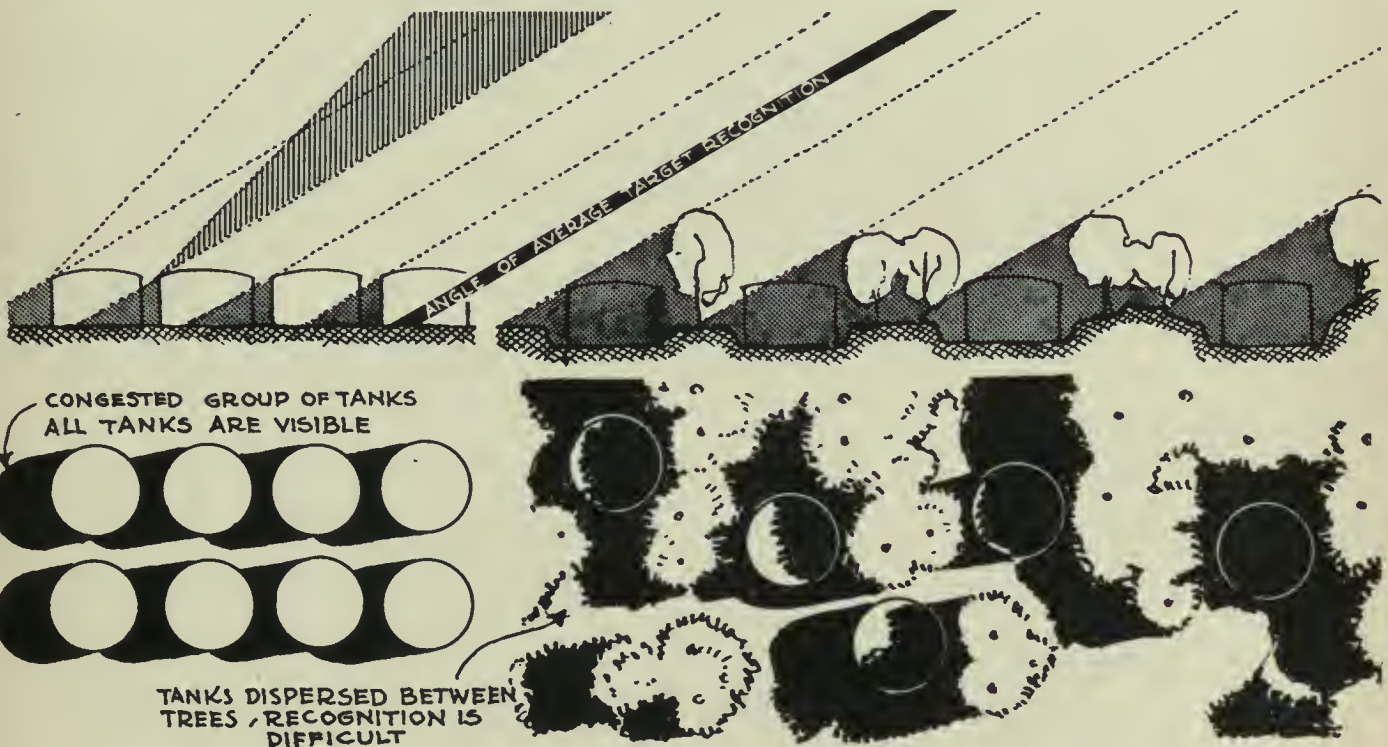
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ANGLE OF RECOGNITION



The dark areas are not
seen from the airplane

The angle for average target recognition is 30° to 44° ; for minimum target recognition, 40° to 52° . Lower flight and higher speed correspond to smaller angles. Expected altitude of bombing, and probable angle of recognition determine projection or extension of super-structures, of nets, hoods, roofs, or protective planting.



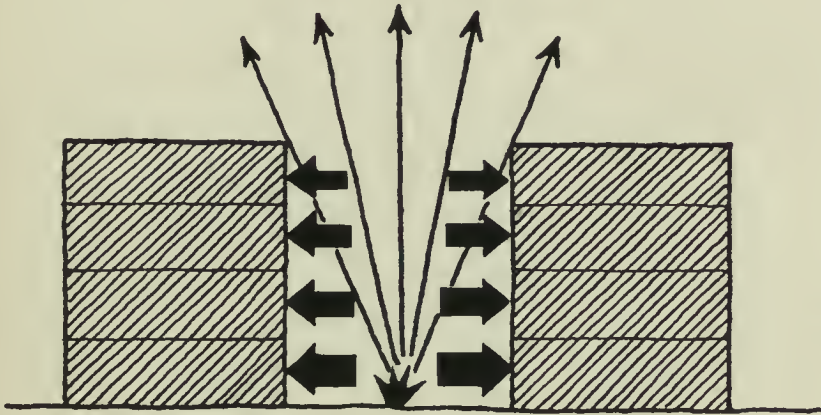
Freight yards, railroad sidings, large tank farms are easily spotted from any angle. But dispersed sidings, spreading fan-like between trees, and dispersed tanks in open lay-out use the sight protection through trees to good advantage. The black areas are in the sight-shadow of recognition. Camouflage, if necessary at all, would be much easier.

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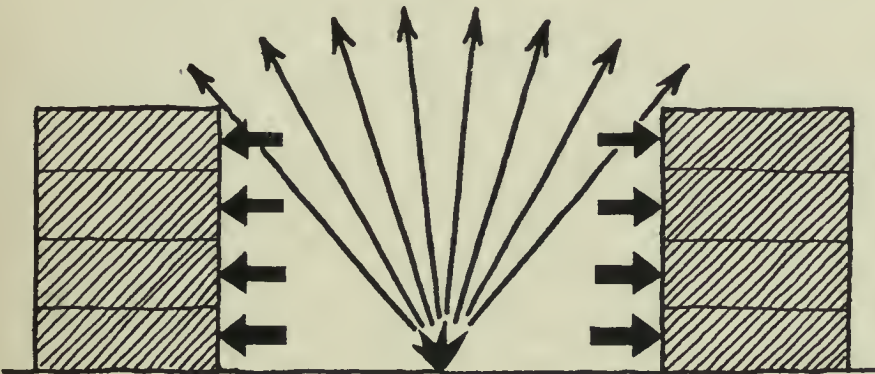
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EFFECT OF EXPLOSIONS: HIGH AND LOW BUILDINGS



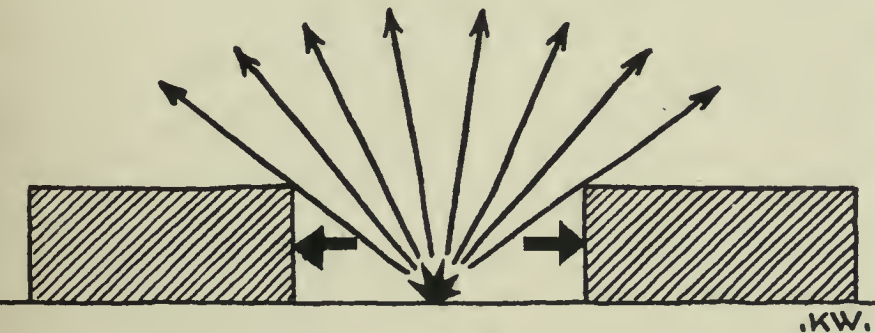
The force exerted by expanding gases and air pressure is in proportion to the strength of the resisting surfaces.

An explosion confined by strong masonry is tremendously increased in violence because it is so confined.



The violence of explosions is therefore relatively much greater in narrow courts or narrow streets as compared with wider streets of the same height.

The size of the arrows indicates the force exerted by air-pressure.



One-story buildings offer less resistance to air pressure than multi-story buildings; therefore they are less vulnerable: air-pressure can escape more easily.

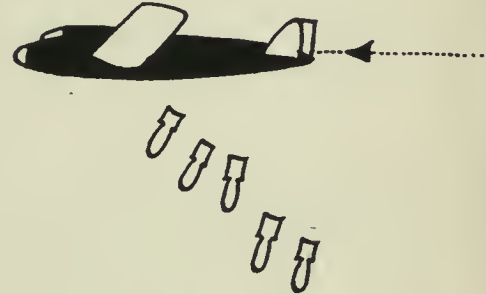
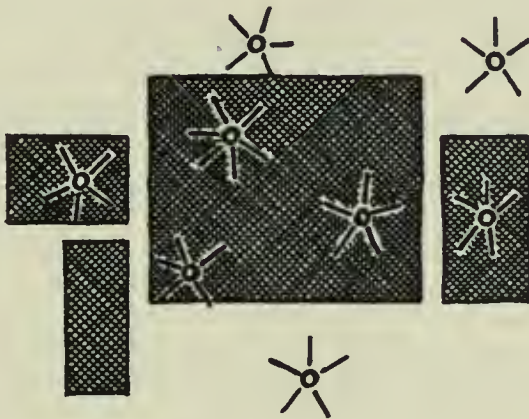
Consequently, lower buildings are preferable.

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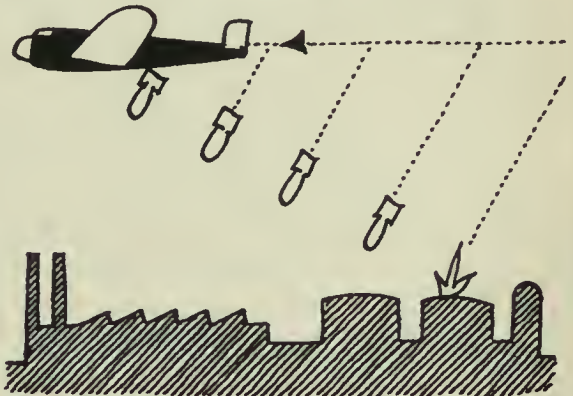
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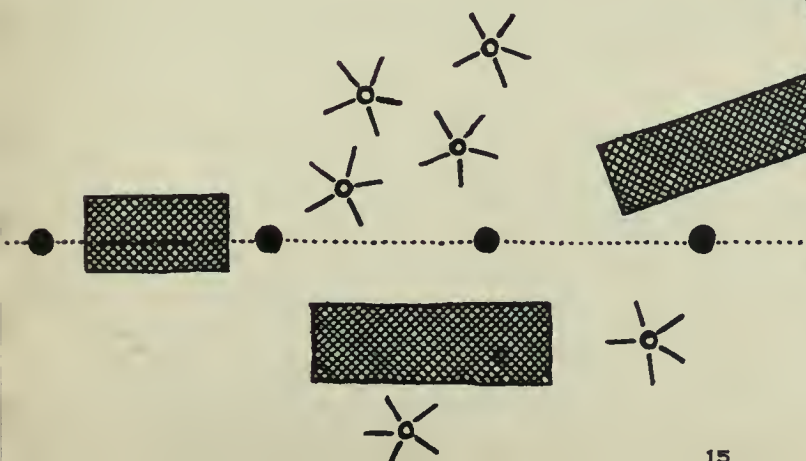
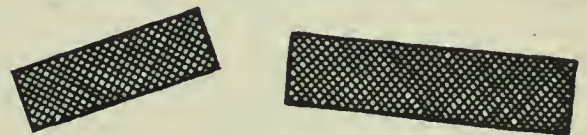
EFFECT OF EXPLOSIONS: CONCENTRATED AND OPEN LAYOUTS



A large square building or a congested group of buildings offers a good target, easy to aim at and profitable to bomb. The plane drops a salvo of bombs, resulting in many hits.



Long and narrow buildings offer a comparatively poor target for a salvo of bombs. But they are relatively vulnerable, if very long, for a stick of bombs, because the long extension makes it easy to envisage and dive at.



The safest lay-out for "salvos" as well as "sticks" is therefore the arrangement of long, but not too long buildings, spaced with intervals, and so placed that the buildings are not in one line.

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CRITERIA OF EFFICIENCY OF INDUSTRIAL PROTECTION

What we aim to achieve:

A

We want the target to be

1- difficult to find

reduction of visibility -
concealment - confusion -

2- difficult to hit

decentralization - layout -
planning - natural protec-
tion.

3- unprofitable to bomb

decentralization - dis-
persion of industries
and buildings -

B

After a hit has occurred
we want to

1- localize damage

subdivision of buildings
and supply lines -
new constructions -
fire-fighting precautions -

2- avoid interruption
of work

protection of vital machi-
nery and men -
safe stock of reserves -
use of domestic resources -

3- make repairs easy

simplicity of construction -
intersections -
repair facilities -
domestic materials -

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ANALYSIS OF A FACTORY

All suggestions and designs for aerial bombardment protection should begin with a thorough investigation of merits and demerits of the plant, its location and its internal organization. The probable altitude of attack and possible lines of approach are important factors. Very often toning down reflections and obviously visible structures like chimneys and white pavements may be sufficient to remove the distinctness of a desirable target, with additional precautions to reduce the vulnerability of the plant.



- ① Factory built on open terrain in marked contrast to landscape, and therefore easily detected.
- ② Lack of ground defense opens it to attack from low altitudes; a vital factor in determining any proposed camouflage scheme
- ③ Residential areas are removed from plant. Country is rural, with no obvious landmarks.
- ④ Geometric pattern of highways and paved roads in distinct contrast to dark roofs.
- ⑤ Light buildings conspicuous. Parapets, vents, the chimney, show strong reflection. Profitable target for precision bombing.
- ⑥ Buildings detached and not high. Few narrow courts. Explosion would not be too confined.
- ⑦ Layout of factory is good and surveyable, with access to all buildings from all sides.
- ⑧ Big glass areas would decrease effect of internal explosion, but breakage of glass would be considerable.
- ⑨ Area devoid of trees which would help confuse pattern and conceal decentralized parking.

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GENERAL APPROACH FOR ANALYZING INDUSTRIAL AREAS

Observations are necessary with regard to:

Dangerous locality:

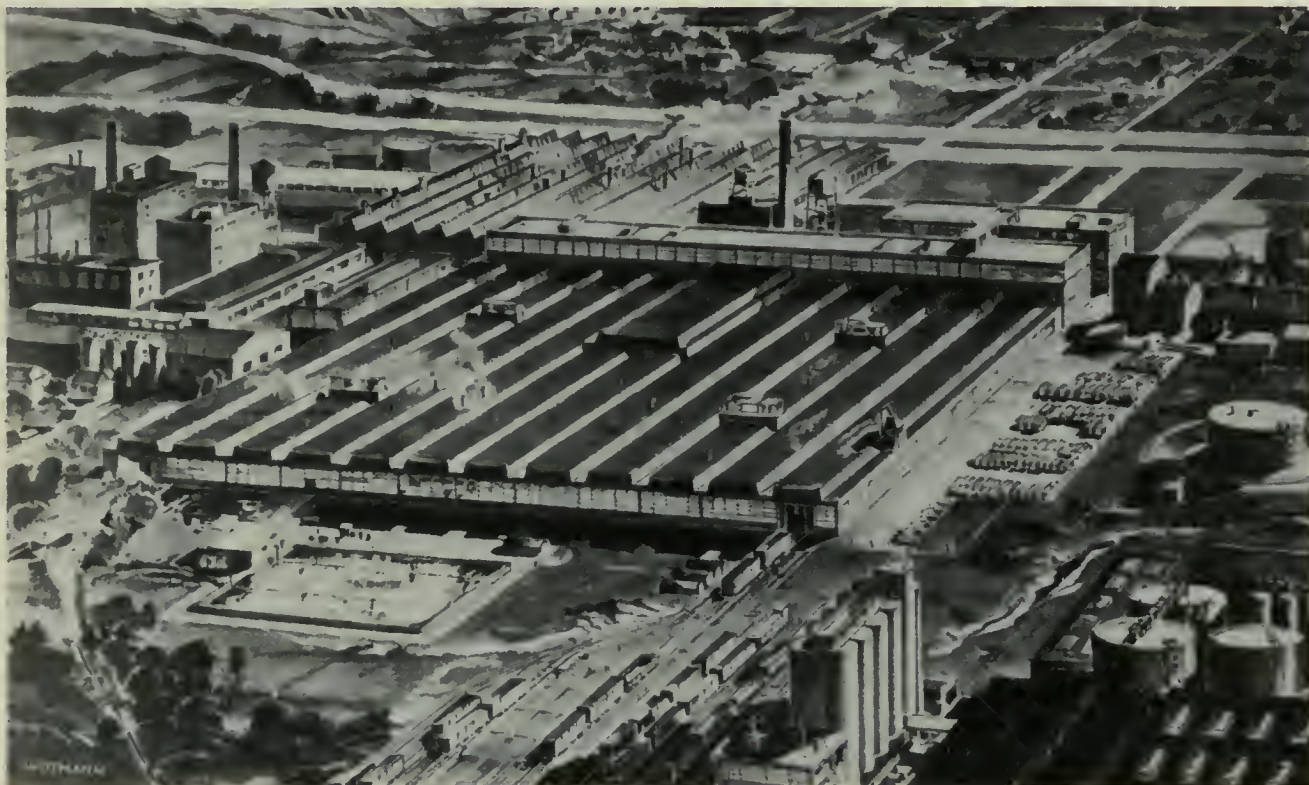
- 1 conspicuous landmarks
- 2 unplanned neighborhood
- 3 road bottlenecks
- 4 obsolete structures
- 5 unorganized supply
- 6 lack of fire protection

Dangerous visibility:

- 1 Reflection glass areas
- 2 bright and metal roofs
- 3 tanks, chimneys, smoke
- 4 pavements, sidings, water
- 5 shadows, high structures
- 6 straight & angular lines

Dangerous vulnerability:

- 1 great spread under one roof
- 2 congestion & narrow courts
- 3 inadequate construction
- 4 inaccessibility
- 5 over-sized glass surfaces
- 6 exposed utilities



Suggestions for Camouflage and Protection should be made:

To improve the locality:

- 1 collective defense planning
- 2 neighborhood rehabilitation
- 3 opening by-roads & highways
- 4 improved building codes
- 5 supply inter-communications
- 6 more regional organization

To reduce visibility:

- 1 painting, toning down
- 2 using screens, nets, boards
- 3 protective hoods and roofs
- 4 darkening or covering roads
- 5 distortion of shadows
- 6 landscaping program

To reduce vulnerability

- 1 subdivision
- 2 dispersion of buildings
- 3 reinforcing structures
- 4 streamlined communication
- 5 fire and blast bulkheads
- 6 duplicating utilities

Camouflage suggestions should include:

1- A survey of the topographical situation, covering landmarks, possible lines of approach, uncamoouflagable features which hamper the expected effect

2- Necessary recommendations for large-scale arrangements.

Plans for general protection should consider:

1- The situation if camouflage fails or is impossible, or if material or labor is not available

2- Recording necessary interior changes, protective measures for shelter, and problems of management.

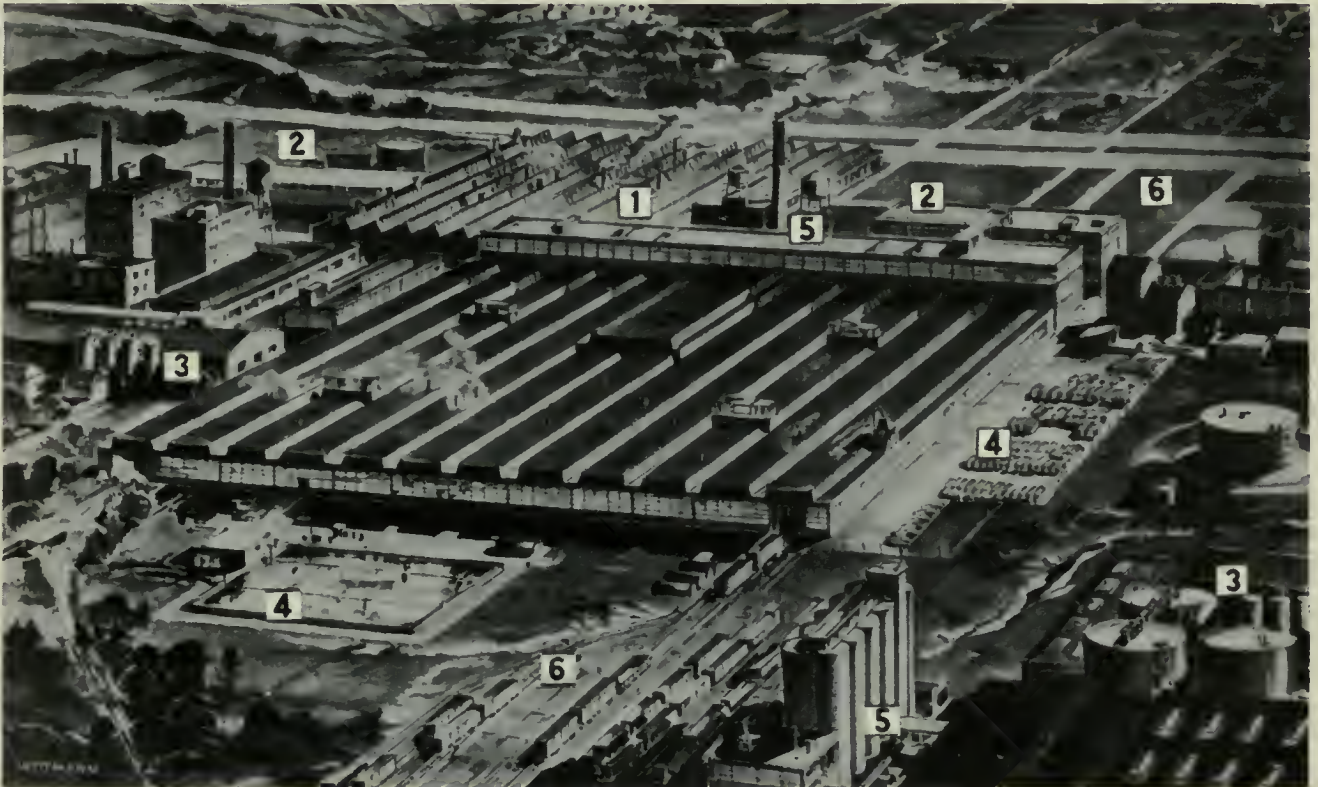
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DANGEROUS VISIBILITY

A- Observations - This picture of an industrial area demonstrates typical features of conspicuousness: The long rows of parallel windows with reflections and shadows, long, flat roof, and - especially vulnerable - sawtooth roofs. Vents, exhausts, skylights, tanks, circular tank embankments are very obvious. The vertical lines of the silo are visible at great distance. Straight roads leading to factory, parking fields, and the railroad siding are conspicuous in size and by reflectivity of car-tops. Water surface, very near building, is regular in shape, and contrast of roof and pavement gives obvious angular lines.



B- Suggestions to reduce Visibility:

- 1** Reflecting glass areas, especially skylights, should be reduced by boarding up or coating with oleo-resinous adhesive paints.
- 2** Roofs should be darkened with dark roofing paper, bituminous emulsions, cold-water protein paints, or emulsified resins. Tanks, vents, and metal roofs should be coated with lusterless enamels, oil paints, bituminous emulsions or adhesives. Camouflage superstructure of nets is more advisable than pattern-painting.
- 3** Valuable tanks containing inflammable substances should be hooded - fading out in screening - against bullets and splinter-hits.
- 4** Parking fields should be darkened irregularly by fibrated bituminous emulsions, oleo-resinous traffic paint, or topping asphalt. Roads should be patterned with asphalt, tar emulsions, or watergas tar, combining granulation and color treatment. The cheapest method of covering basin would be with nets.
- 5** High tanks and chimneys should be screened to obliterate shadow. Screening should be thin over flat roofs, but thick over reflecting elevations or long shadows. Silo should at least be painted dark.
- 6** Trees should be planted on wide-open areas, and neglected or bare spots to reduce the geometric pattern and blend landscape and industrial area. The railroad siding should be removed, and cars placed under shadow protection of trees.

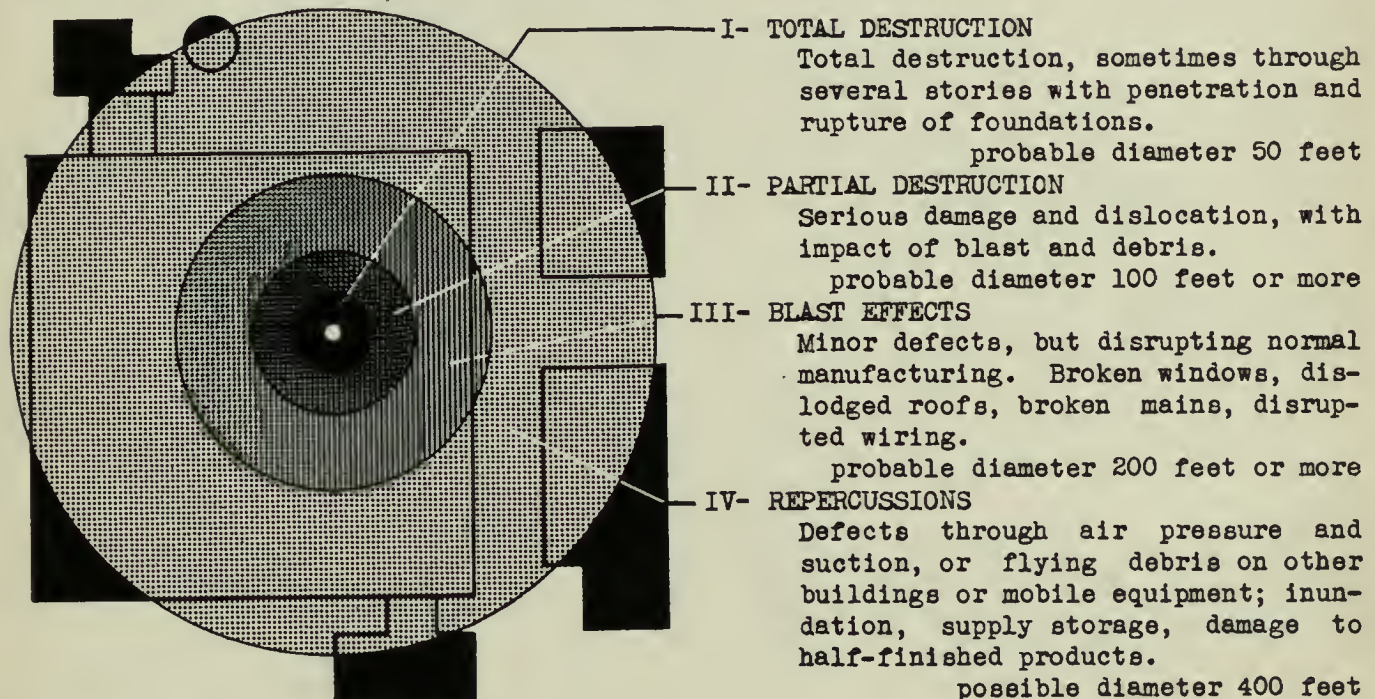
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EVALUATION OF DESTRUCTION

For those who question the advisability of protective measures, or for those who want to estimate the scope of possible damage, it is suggested that this sheet be filled out, estimating the destruction through an imaginary hit anywhere within or outside the plant. This enumeration considers only the effects of demolition bombs, not of incendiary bombs and of spreading, uncontrollable fire. It is assumed that personnel has been evacuated with ample warning.



EVALUATION

(For a hypothetical case)

	Value destroyed in dollars	Delay in man hours	Efficiency diminished in % of program	Schedule disturbed in days & months
A- Effect on Buildings: Structures destroyed, constructions weakened, windows broken, roofs blown off	\$83,000	20,000	20%	30 days
B- Effect on Equipment: Machinery destroyed, tools lost, transmission and assembly lines disrupted	73,000	15,000	5%	60 days
C- Effect on Utilities: Mains, valves, switches broken; wiring disrupted; inundation	20,000	5,000	20%	10 days
D- Loss in nearly-finished stock: Delay in production output	36,000	10,000	30%	30 days
E- Difficulties of Replacement: Loss in time, changes in mfg. process	20,000	5,000	20%	15 days
Total:	\$232,000	55,000		

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AERIAL SAFETY FOR FACTORIES

FIRST STEPS IN PREPARATION FOR EMERGENCY

Testing

Checking of safety of constructions under stress of explosions.

Study of distribution of valves and accessibility of mains.

Checking of visibility and dangerous reflections.

Accessibility of all structures.

Study of vulnerability of valuable machinery.

Checking vulnerability of water towers.

Experimenting

Practical experiments with camouflage material.

Dimming or elimination of reflections.

Painting for protective coloration.

Testing of black-out materials.

Installation of fire - fighting equipment.

Study of repair facilities.

Planning

Elimination of bottlenecks of roads and railroads.

Plan for extension of supply lines and use of natural water resources.

Additional supply buildings. Subdivisions and interconnections.

Protective structures over windows and exits. Reduction of glass area.

Building of shelter and facilities for quick dispersion of workmen.

Elimination of parking areas.

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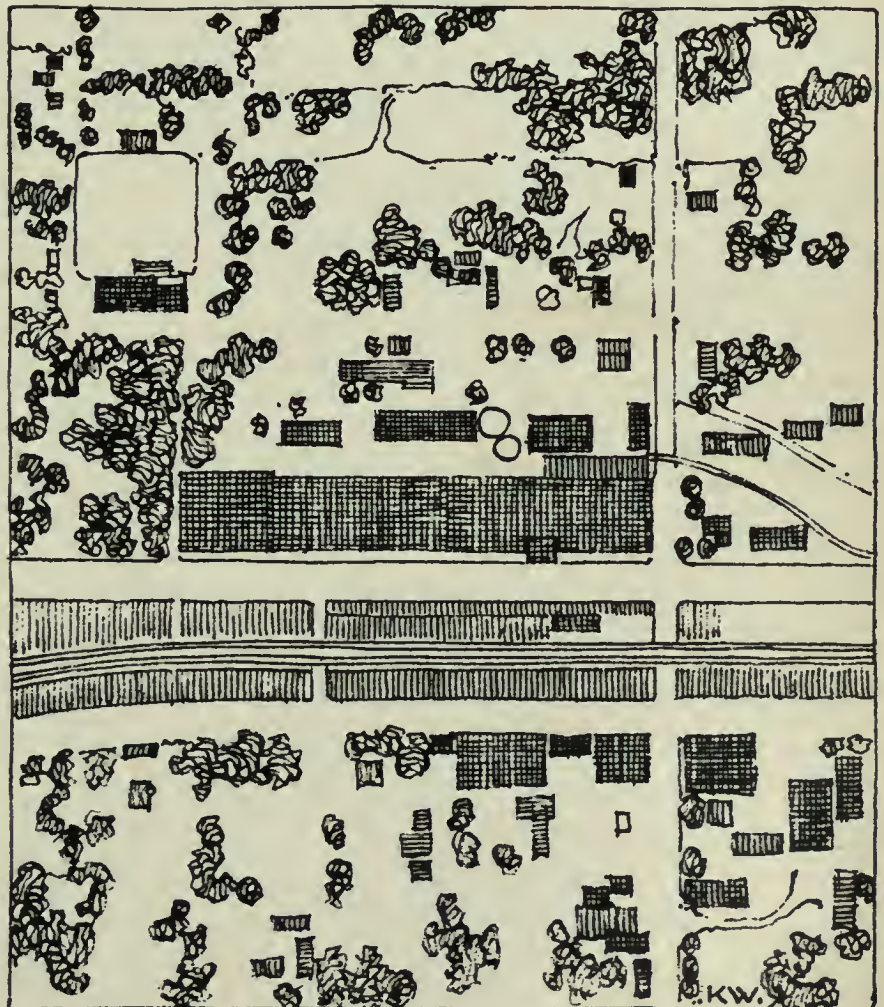
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GENERAL CONSIDERATIONS FOR FACTORY SITE I



A long, low, dark building is relatively less vulnerable than a congested building which has all manufacturing facilities under one square roof. It is, however, to the disadvantage of this factory that it is easily located because the dark roof is in such sharp contrast to the white street and the regular squares of the station plaza.



The sketch illustrates the conspicuousness of parallel, sharply outlined dark and white stripes within a landscape which is checked with various spots of dark and light fields. It is easy for the pilot, following the railroad, to detect these parallel lines and to aim at them.

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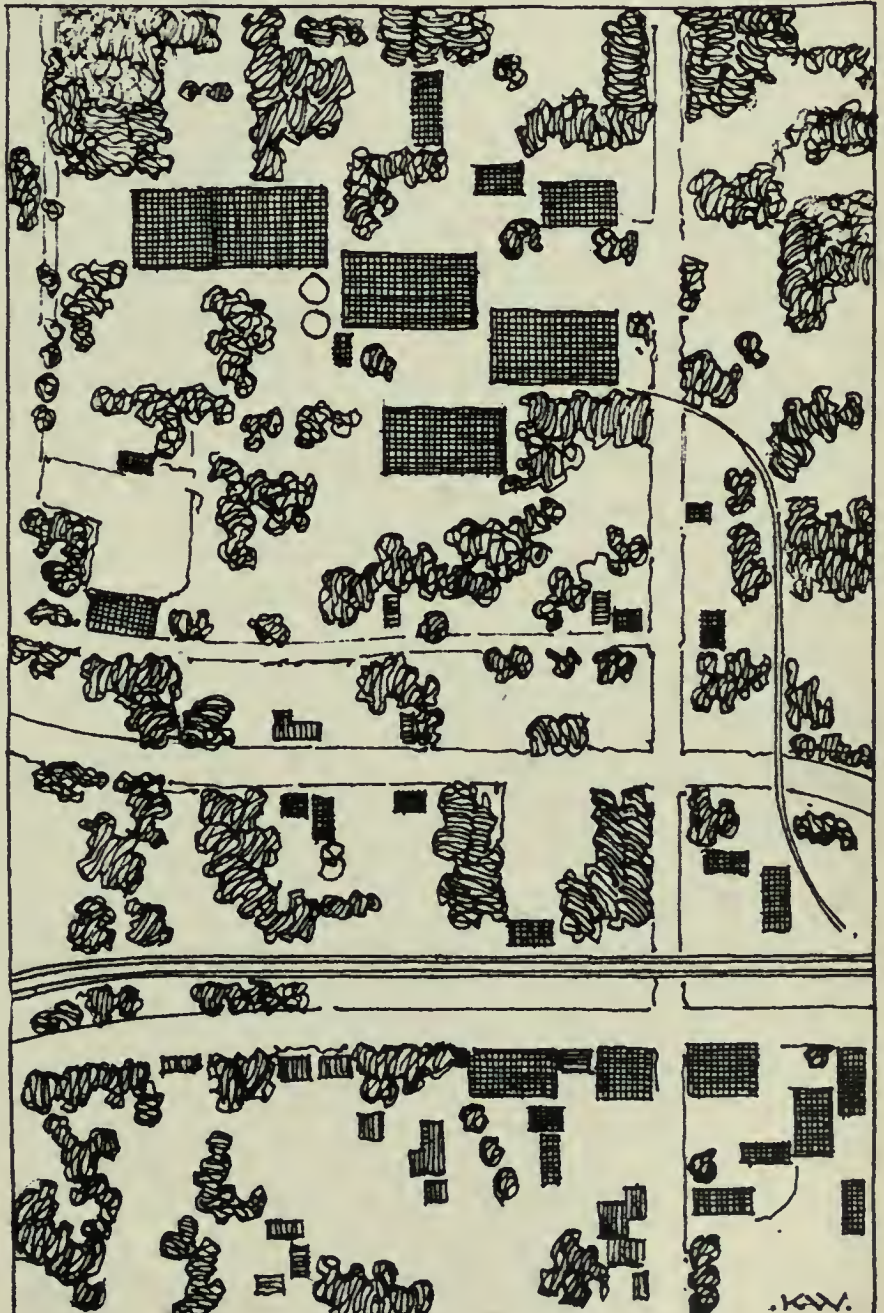
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GENERAL CONSIDERATIONS FOR FACTORY SITE II

Sub-division of a manufacturing plant into several separate, not-too-large buildings, has the following advantages:

- 1- The chance of internal explosions, which could destroy the entire factory is reduced. Explosions and damage are more localized.
- 2- Access to buildings from all sides is better.
- 3- Fire doesn't spread as quickly and is easily restricted to one unit.
- 4- Camouflage and blending with the natural pattern of the surroundings is easier.
- 5- Additions in the form of separate buildings look more natural and do not make the target bigger.
- 6- The grouping of buildings very often reveals better architectural values.



The erection of this factory, somewhat removed from the railroad and in the form of separate buildings, would have had the advantage that the buildings blend inconspicuously into the natural pattern of the landscape.

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PROBLEMS OF LONG BUILDINGS I

Conspicuousness of Site



Protective concealment is effective only as a total job, comprising not only the factory proper, but also driveways, roads, railroads, other buildings adjacent to the factory and even landmarks at some distance.

This factory, long, low and dark, has certainly the merit of inconspicuousness. It shows a well-organized grouping, accessibility from all sides, which is an advantage in case of fire, and for the flow of materials and workers.

However the conspicuousness of streets along the factory, the layout of the new housing developments, the rows of white houses in contrast to the old village, make a bull's-eye target, with a dark center in a bright field. It is easy to locate such a target from the sky.



In contrast to the revealing view above is this plant designed for inconspicuousness as an advanced type of design, where buildings, roads, and all the other facilities of a factory are definitely conceived as an integral part of the landscape. The plant is only an insignificant part within the bigger pattern of the landscape. We have to think in terms of appropriate scale if we want to apply the lessons of pattern adaptation in nature to industrial plants.

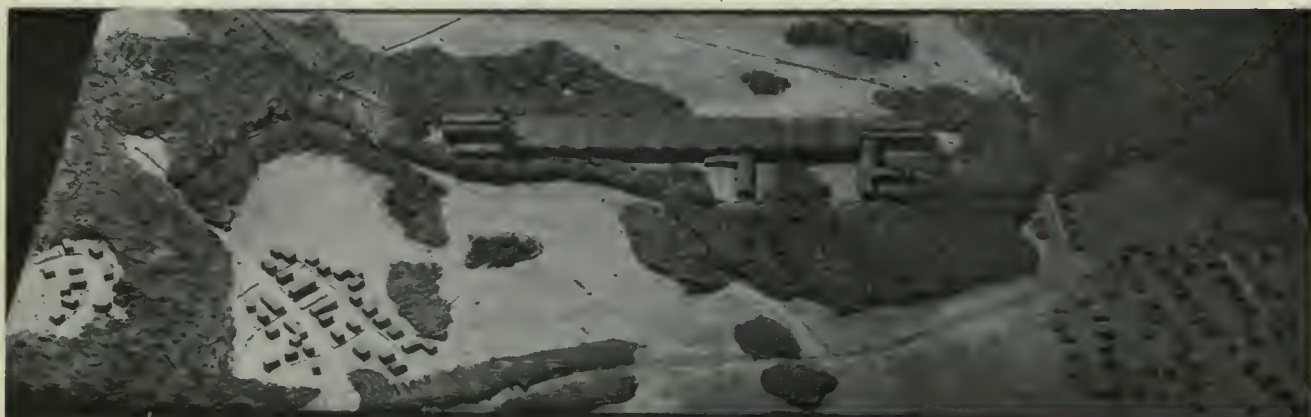
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PROBLEMS OF LONG BUILDINGS II

Contrast and harmony with landscape contours



Example of a factory, hidden in woods, but of long extension. The obvious contours of woods do not correspond with the lines of the factory.

The factory is so placed between woods that no line which might be used as a guide to envisage the target, leads to the building. Parallel lines, especially of accompanying streets are avoided. Highway and railroad are at a proper distance.

Special consideration is to be given to road and railway connections. The camouflage of an open system of roads is difficult. It is advisable to make roads as inconspicuous as possible, following the edge of the woods, and no wider than necessary. Parking fields  are placed under the trees.

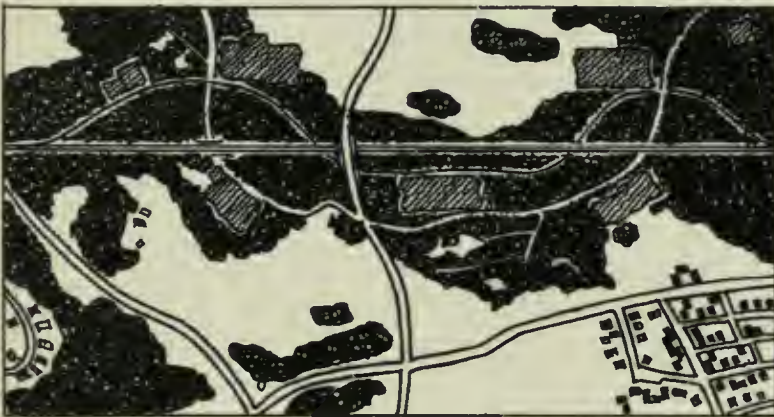
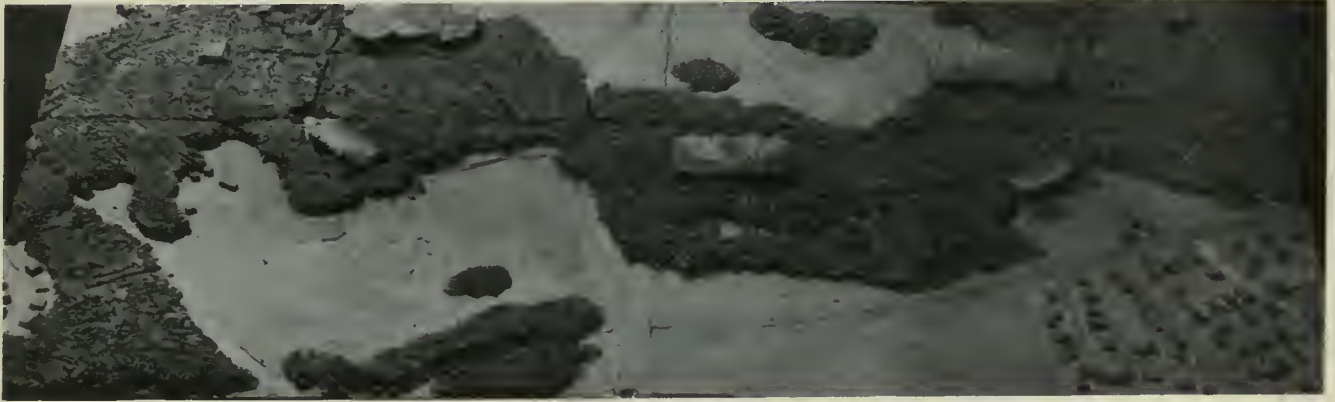


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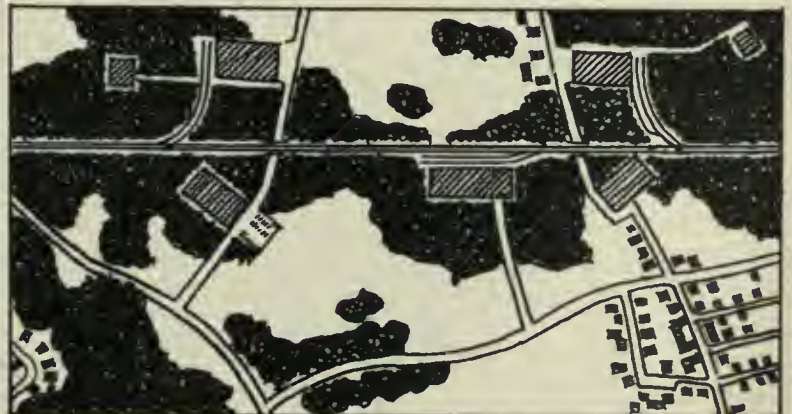
SAFER DESIGN WITH DETACHED BUILDINGS



Detached buildings, placed inconspicuously in woods, at the edge of woods, or in clearings, in harmony with natural contours, give a high degree of safety even without protective camouflage.

This reduction of visibility, which makes a poor target, is only achieved, however, if all the access roads, parking fields, railroads, sidings loading platforms, and all the unavoidable open spaces around buildings maintain perfect "camouflage discipline". The straight main railroad runs through the wood as if no factory existed.

Still better than having a main railroad cut straight through the woods, would be to have the main tracks at a greater distance, and a secondary line, bent into contours, leading to the factory. White, dead-end streets, leading conspicuously to a building, or into a wide parking area, represent a dangerous hazard, as do big clearings in the woods for tracks and sidings.



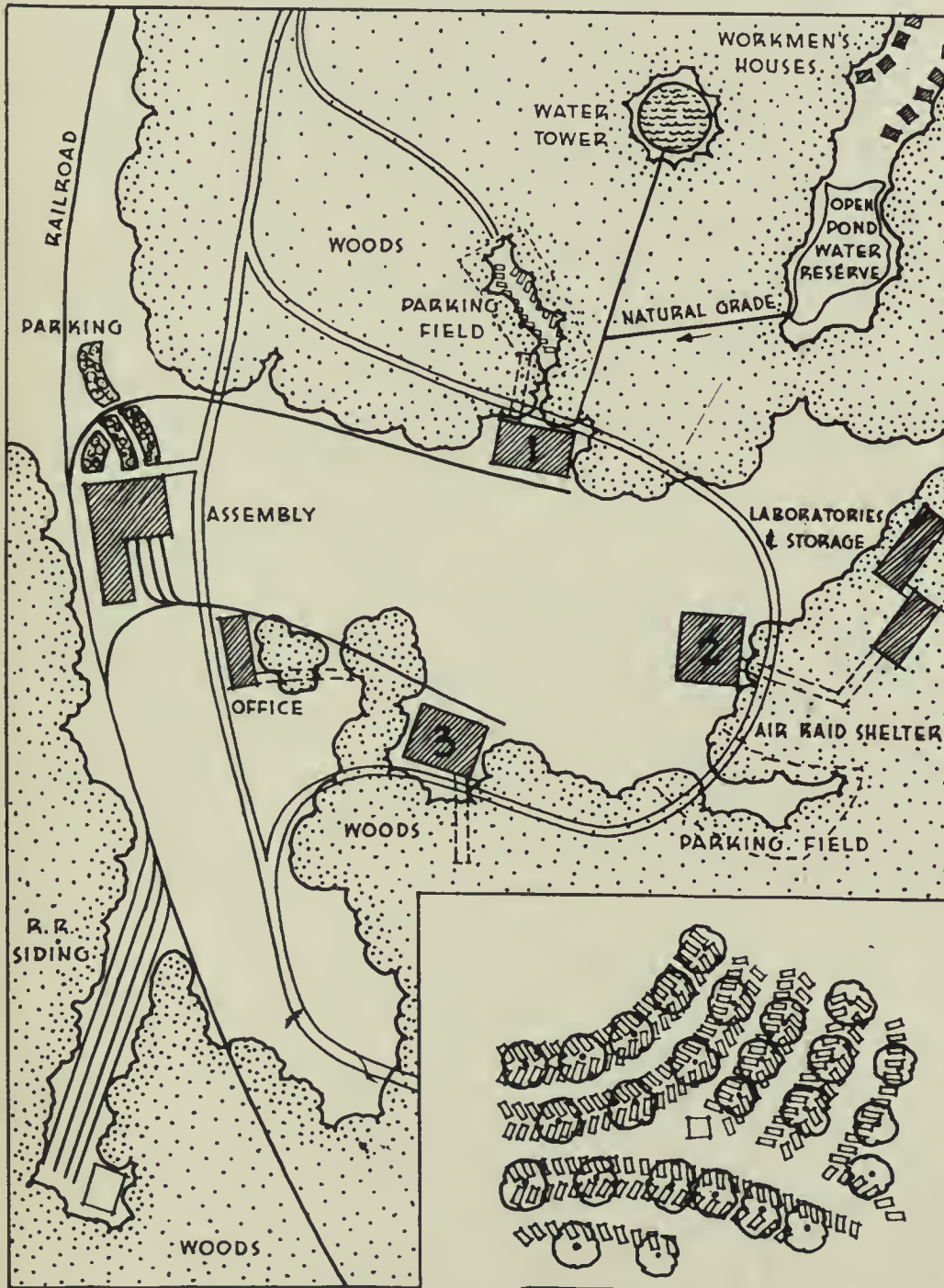
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PROBLEMS OF DECENTRALIZATION

Plant buildings are part of the landscape



City planners have advocated, for a long time, decentralization for the sake of safety, health, and beauty. Their aims receive unexpected support from air - protective design.

Decentralization brings new problems for transportation and supply of utilities. As a whole, the factory needs more space and longer lines of communication. This brings additional building costs, but the advantages are advantages not only under aerial bombardment. Hygiene and a more pleasant architectural aspect of industrial areas are also advantageous.

Irregularly organized groups of buildings are more difficult to find from the sky than regular ones. Placed between woods and trees, in harmony with the general lines of the landscape, they are very difficult to locate from an airplane. Camouflage is easy. The straight lines of parking fields can be covered by trees.

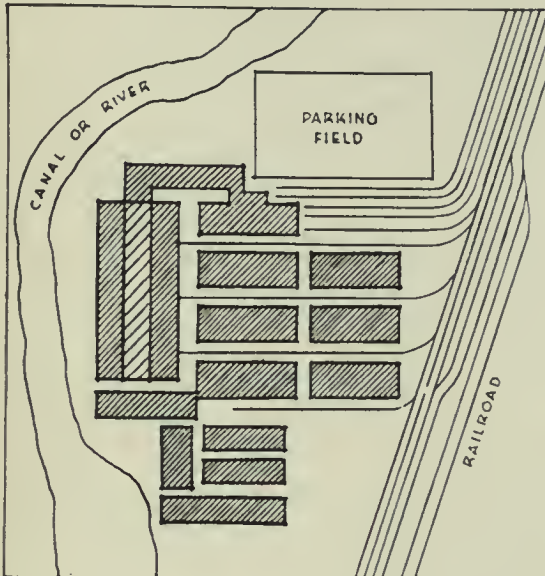
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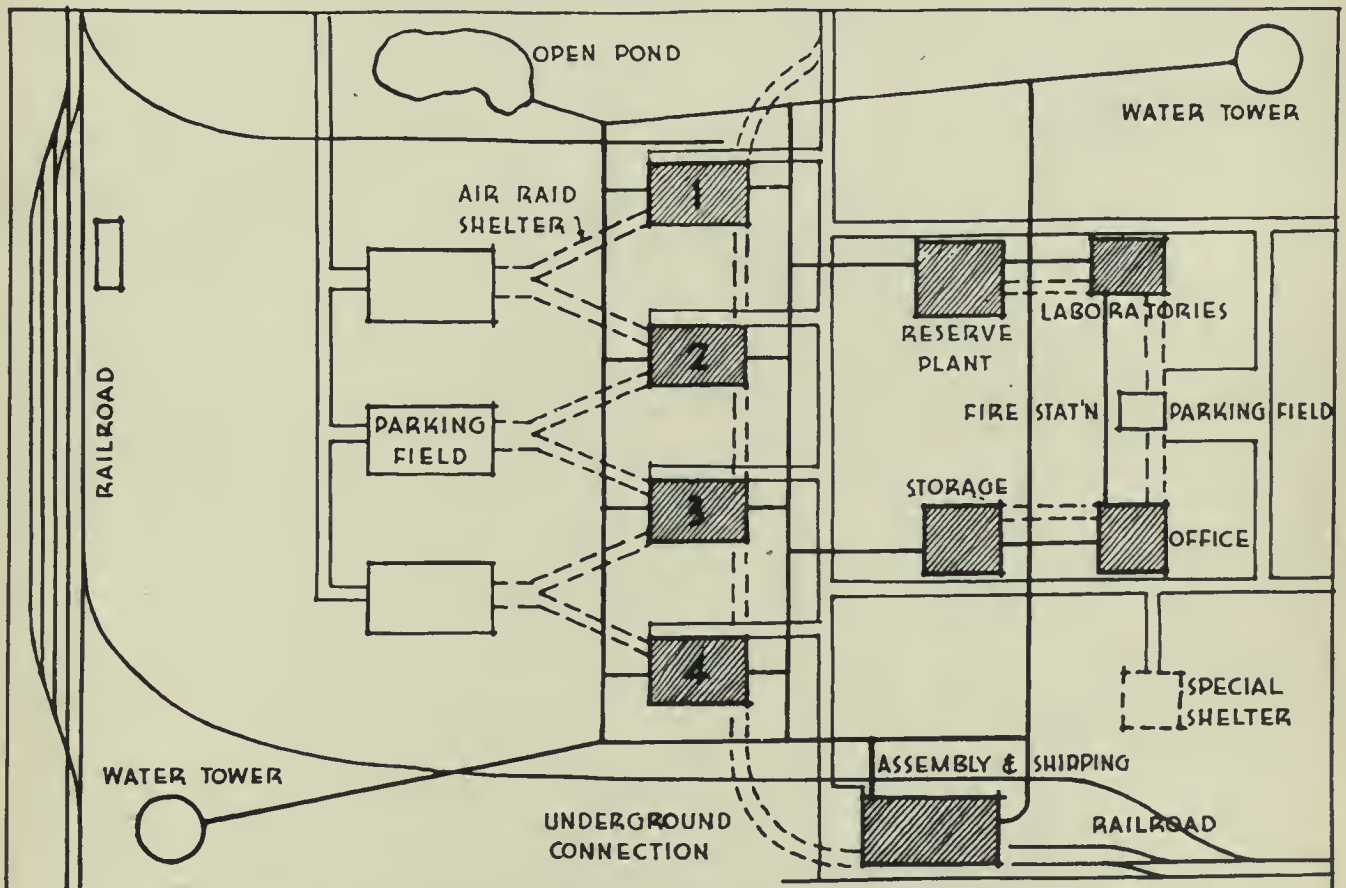
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PROBLEMS OF DECENTRALIZATION

Scheme of a decentralized factory



Factories were built, until now, on the principle of bringing all the buildings as close together as possible, avoiding traffic within the factory. Immediate access to railroad lines, switchyards, and waterways was considered absolutely necessary for the sake of economy. The decentralized factory has to admit somewhat higher manufacturing costs, especially for transportation within and to the plant, for greater safety. Strategic reasons will have to decide which factor should be prevalent.



Scheme of a factory in air-protective design:

- 1- Decentralization of buildings, of air shelter, exits, and parking fields.
- 2- Decentralization of water towers, power stations, storage tanks.
- 3- Two separate railway stations.
- 4- Reserve plant buildings equipped with machinery ready for use.
- 5- Fire towers with training rooms for firemen and air-raid wardens.

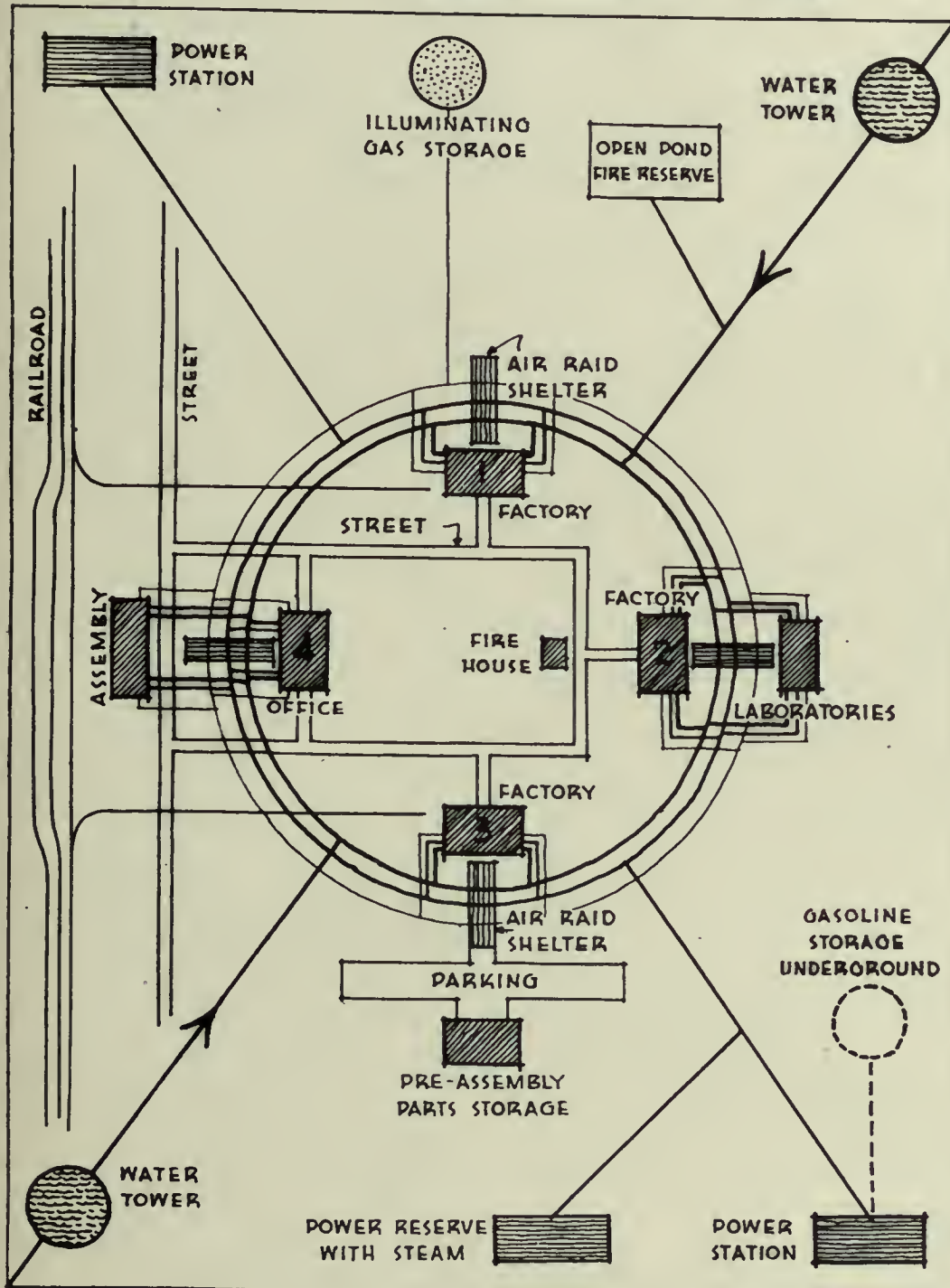
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PROBLEMS OF DECENTRALIZATION

Decentralization of Utilities



From a report of American observers in London:

Putting water mains side by side is a very bad practice. Segregate switches; do not put them all in one place.

Do not depend on one station only; disperse the facilities.

There are not sufficient valves on the gas mains.

Sewers are very vulnerable.

Our watch-word must be "interconnection and standardization".

Theoretical scheme of decentralized plant with supply lines indicating: 1- that power stations, water towers, gasoline tanks have to be built far away from factory buildings; and 2- that every building has to have two separate connections with two separate gas and water mains or electric-supply lines. Proper fire equipment is essential.

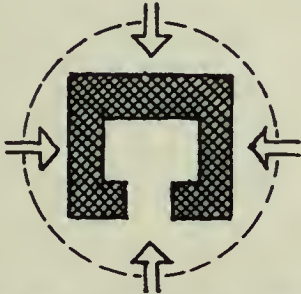
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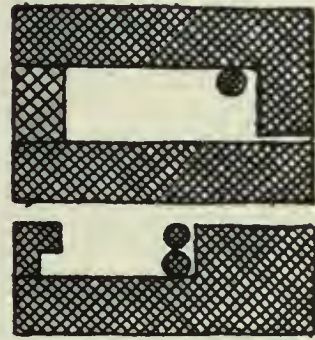
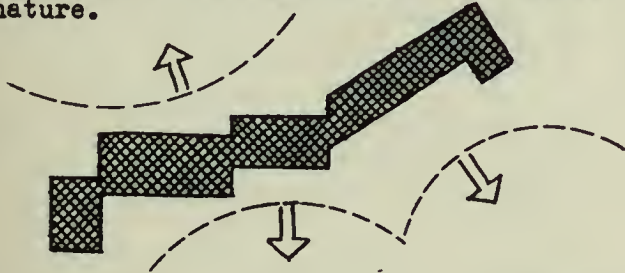
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NEW TYPES OF FUNCTIONALISM

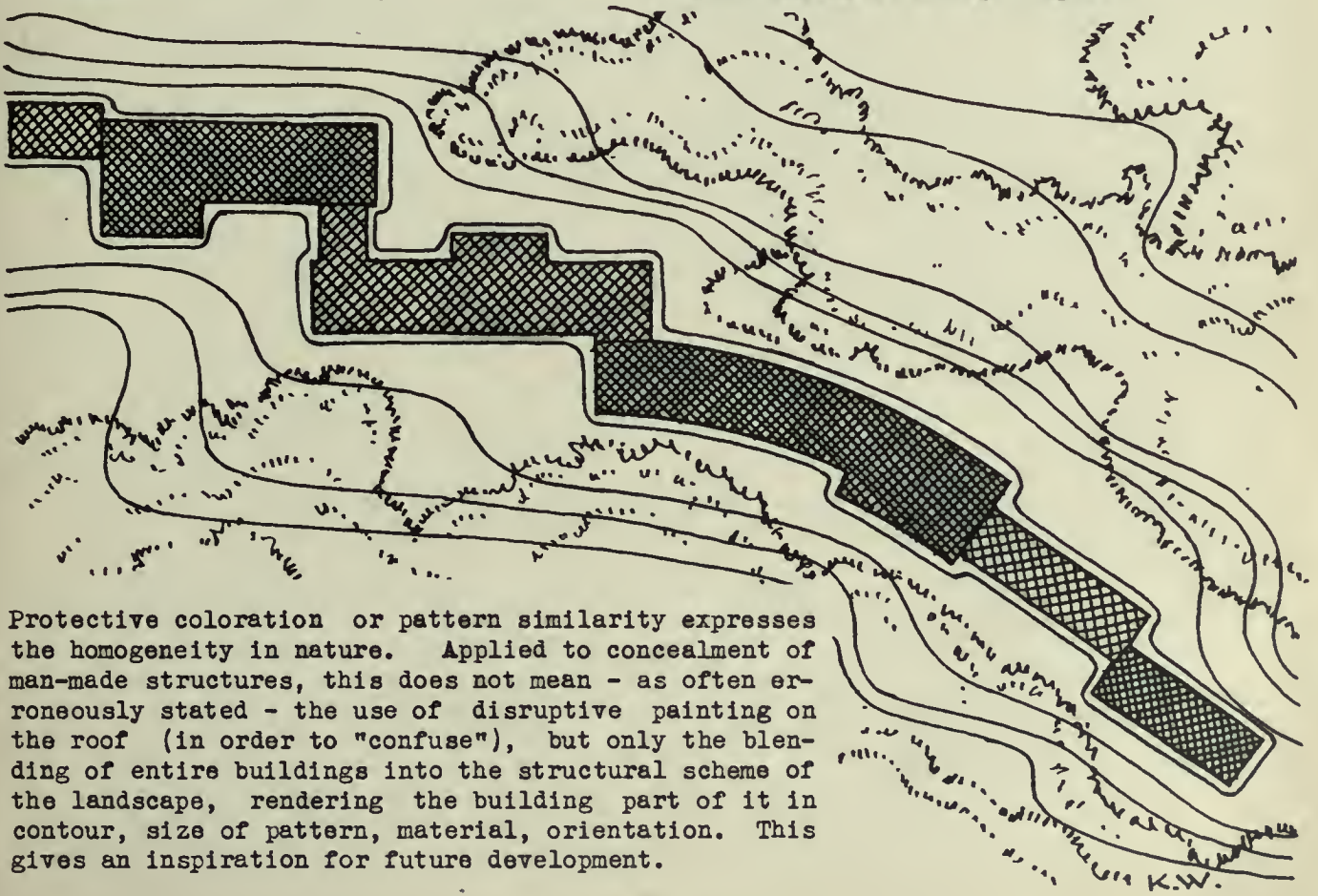
THE RAMBLING DESIGN



Residential architecture tends from conventional and stereotyped forms to freedom and flexibility of rambling design. This trend evidences a growing consciousness of nature.



Factory architecture has new ideals, also: the old mill building, several stories high, a design of dreary industrialization hostile to nature, is obsolete. New designs of flat-roofed buildings follow the contours of the landscape in elastic adaptability to make the building part of the landscape. This design has natural inconspicuousness to a high degree.



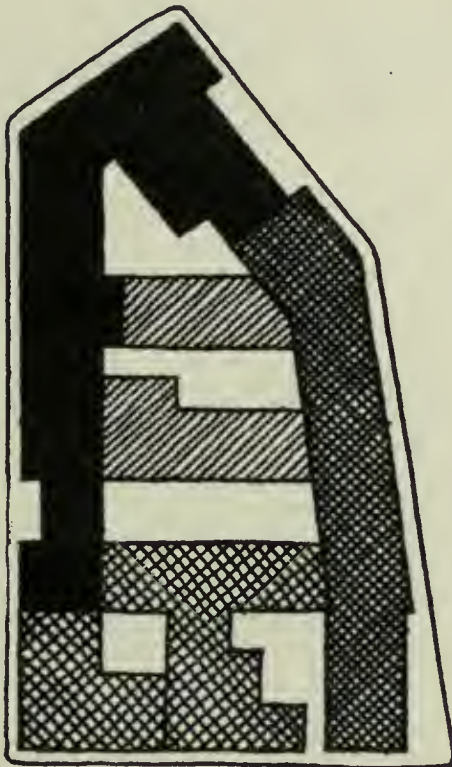
Protective coloration or pattern similarity expresses the homogeneity in nature. Applied to concealment of man-made structures, this does not mean - as often erroneously stated - the use of disruptive painting on the roof (in order to "confuse"), but only the blending of entire buildings into the structural scheme of the landscape, rendering the building part of it in contour, size of pattern, material, orientation. This gives an inspiration for future development.

INDUSTRIAL CAMOUFLAGE

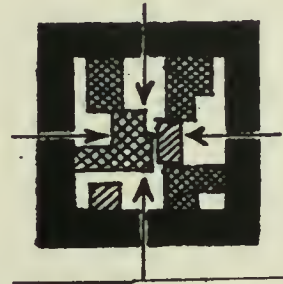
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NEW CONSIDERATIONS FOR FACTORY EXTENSIONS



Example of
irregular
growth.



The centripetal scheme builds first all along the street, later filling up the courts with rear houses and crowded wings.

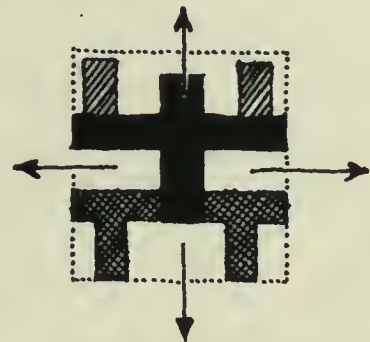
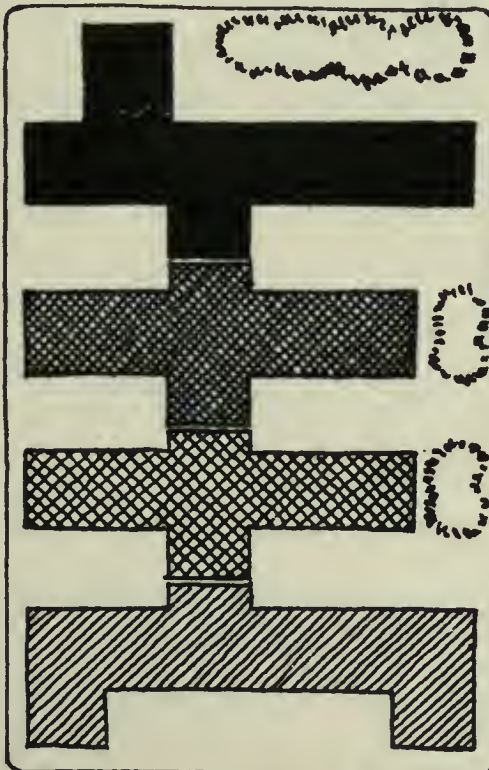
Dangerous congestion is the result if a factory grows on a plot which is too small for expansion, and is confined by existing roads, railroads, or buildings. Narrow courts increase the effect of bomb explosions, and are difficult to reach; succor, fire-fighting, and repairs are hampered. Damage of one section affects all the adjacent buildings.

Example of
planning &
foresight.

First
addition

Second
addition

Third
addition



Centrifugal planning begins in the middle of the block and extends wings radially, always leaving open courts.

Consideration of further expansion should be a part of the first plan. The open lay-out has the advantage of better accessibility from the street; this makes fire-fighting and succor easier. Workmen can be more easily dispersed. Camouflage is easier. Effects of explosions are reduced. Damage of one wing is not so serious and is more easily localized.

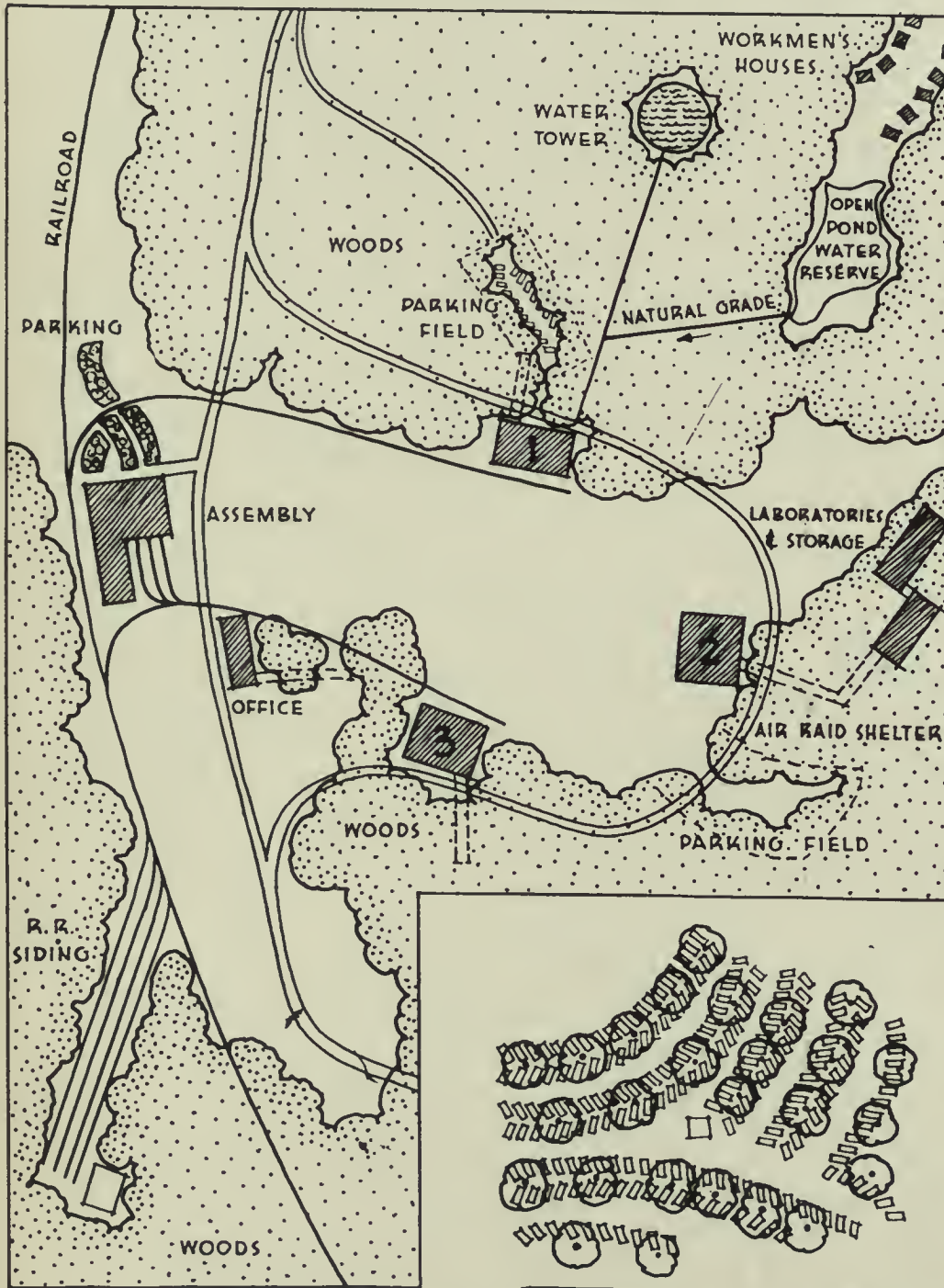
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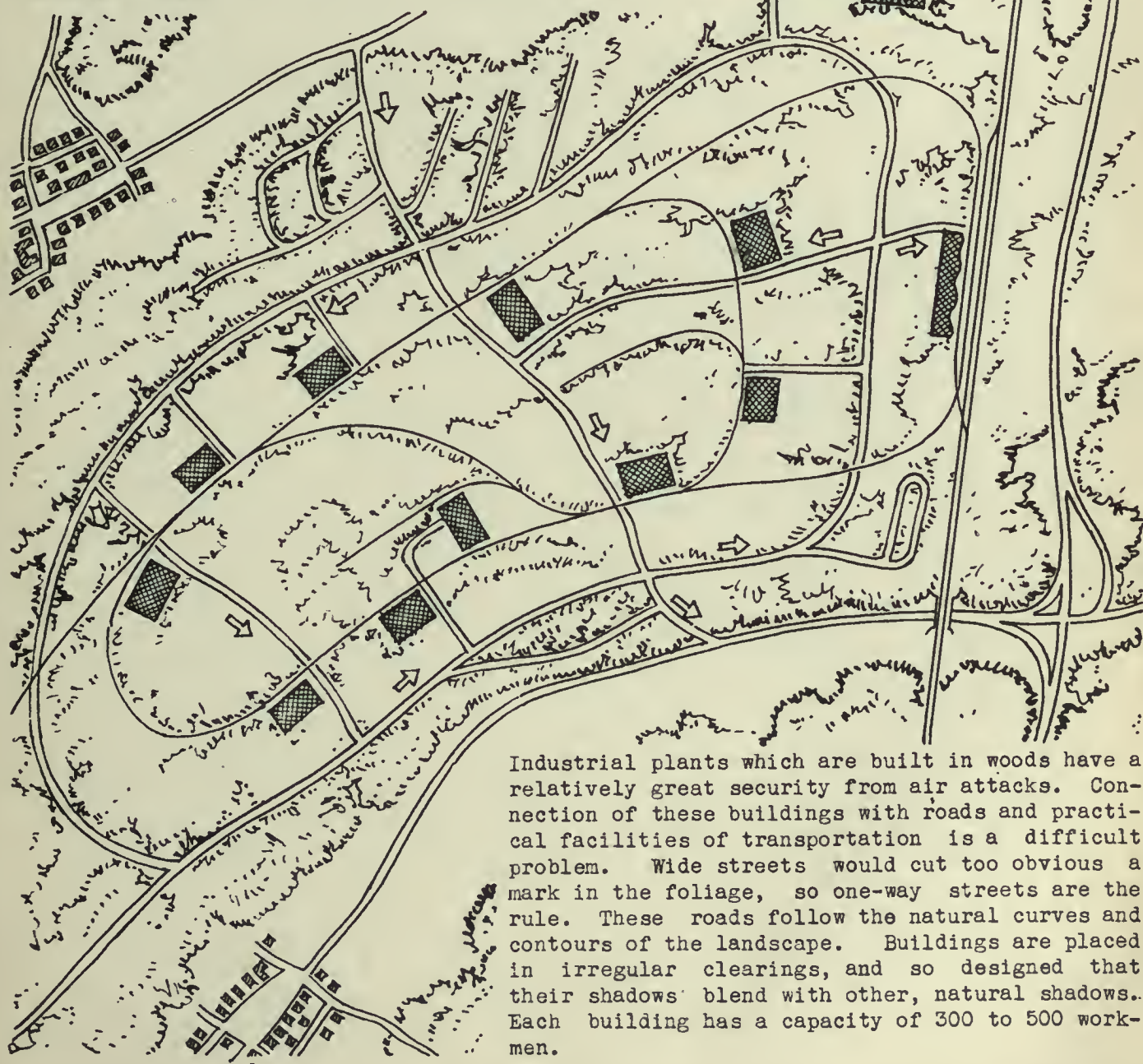
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INDUSTRIAL PLANT IN A WOODED AREA

Large, new, industrial plants have been built in Europe in wooded and remote rural areas, not as a compact mass of buildings, but decentralized in numerous smaller plants and factories, with the trees of the forest forming a vault over the streets connecting the different buildings. A dozen or more separate buildings, each a quarter of a mile or more from the next, give an uncertain target. To bomb a forest several miles in circumference is an uneconomic task.



Industrial plants which are built in woods have a relatively great security from air attacks. Connection of these buildings with roads and practical facilities of transportation is a difficult problem. Wide streets would cut too obvious a mark in the foliage, so one-way streets are the rule. These roads follow the natural curves and contours of the landscape. Buildings are placed in irregular clearings, and so designed that their shadows blend with other, natural shadows. Each building has a capacity of 300 to 500 workmen.

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CAMOUFLAGE DISCIPLINE AS A DESIGN PROBLEM



Given as a student problem, this design for an airplane factory uses the peculiarities of the existing wooded terrain to place the dispersed buildings inconspicuously at a safe distance from each other, and to hide roads, parking fields, railroad sidings, etc. under trees.

Highways and the main railroad pass the site at some distance, only roads of secondary importance lead to the plant. Special thought is given to movement and parking of cars.



- 1- Material Storage
- 2- Foundry
- 3- Workshop
- 4- Experimental Labs.
- 5- Instrument Assembly

- 6- Engine Assembly
- 7- Tail Assembly
- 8- Wing Assembly
- 9- Fuselage Assembly
- 10- Final Assembly

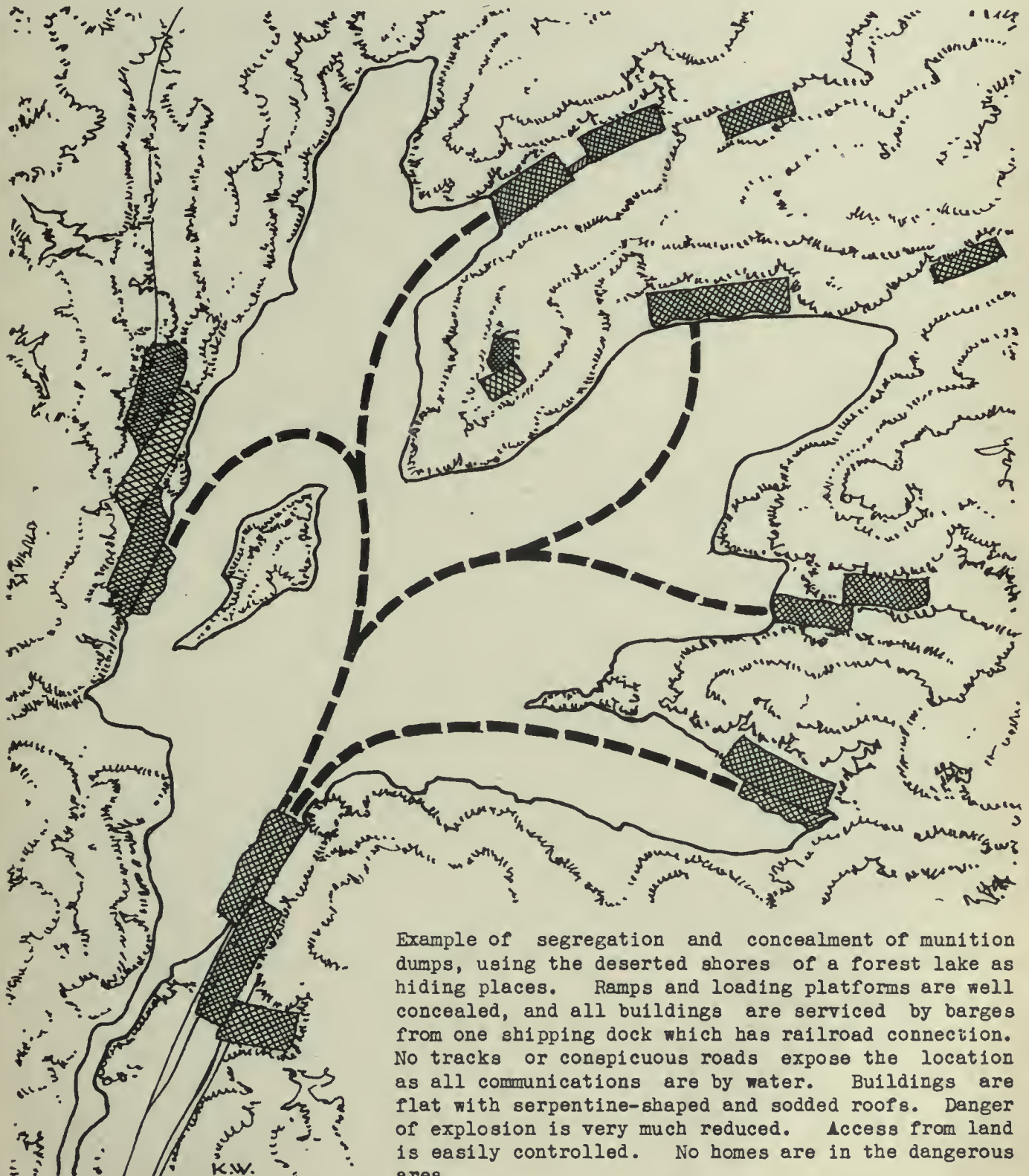
- 11- Shipping
- 12- Reserve Shops
- 13- Railroad Station
- RS- Railroad Sidings
- P- Parking Fields

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CONCEALMENT OF TRANSPORTATION



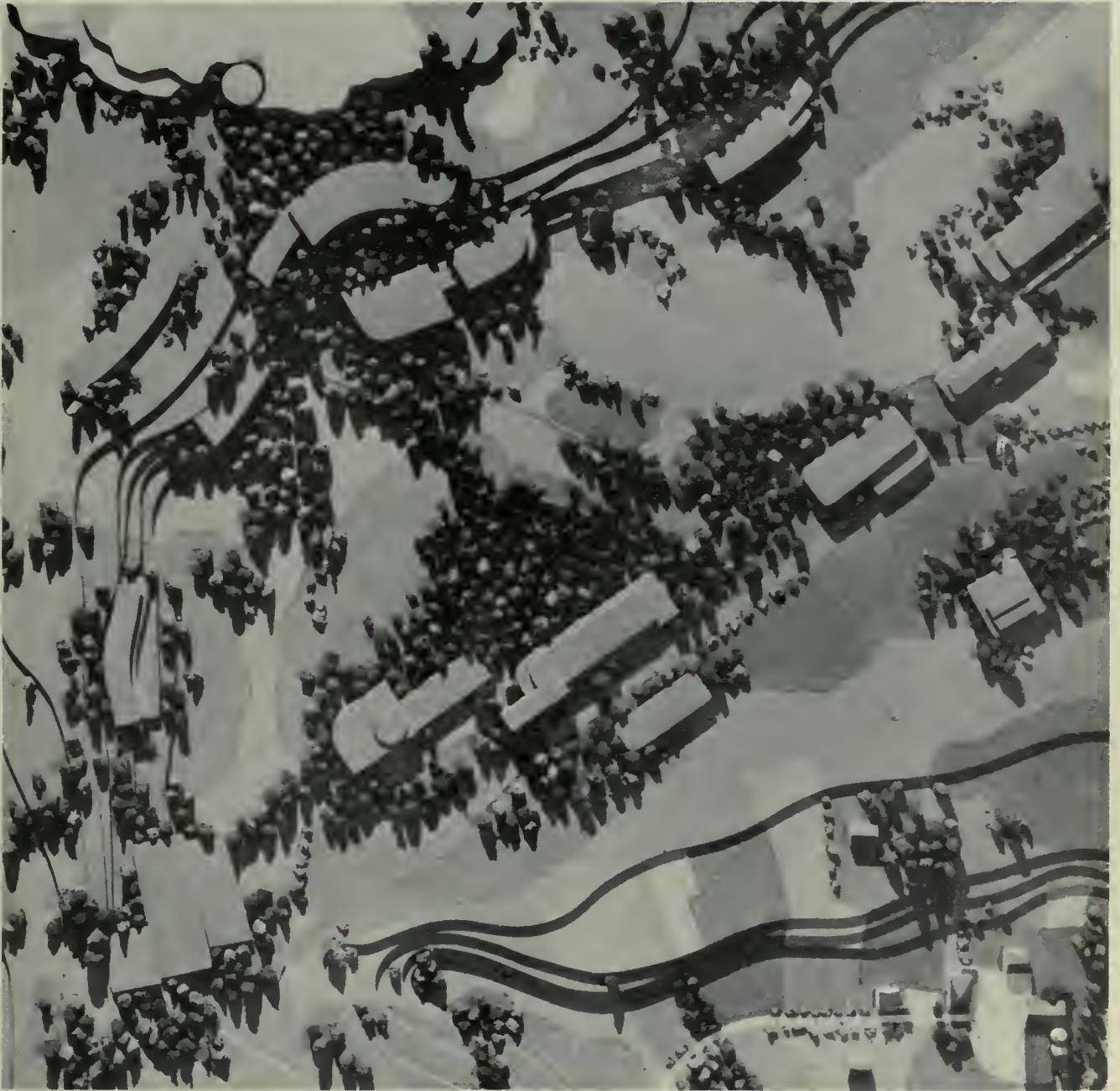
Example of segregation and concealment of munition dumps, using the deserted shores of a forest lake as hiding places. Ramps and loading platforms are well concealed, and all buildings are serviced by barges from one shipping dock which has railroad connection. No tracks or conspicuous roads expose the location as all communications are by water. Buildings are flat with serpentine-shaped and sodded roofs. Danger of explosion is very much reduced. Access from land is easily controlled. No homes are in the dangerous area.

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FUTURE TYPES OF PLANT LAYOUT



Representation, in a vertical view, of new types of plant layout, designed for natural inconspicuousness. One group of buildings (center) is so arranged with detached structures that over-long roof-lines are avoided, although the buildings are lined up along a railroad. The other group, still less visible, is fitted to the contours of the hill and very free in individual design. Arrangements of this kind can blend with the landscape perfectly, much better than on a stylized model.

INDUSTRIAL CAMOUFLAGE

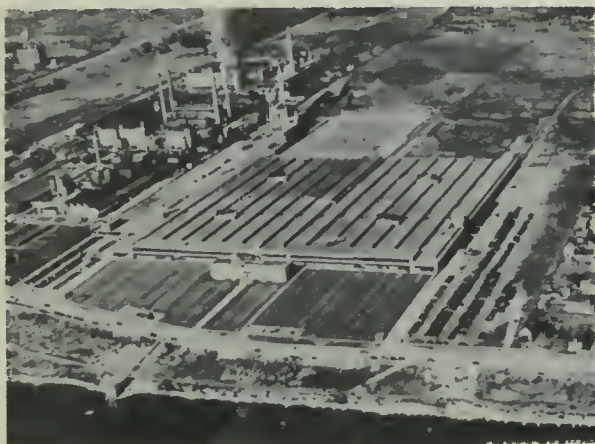
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ANALYSIS AND SYNTHESIS
A Work-program in Stages

1

Developed by Konrad F. Wittmann
Architect A.I.A.



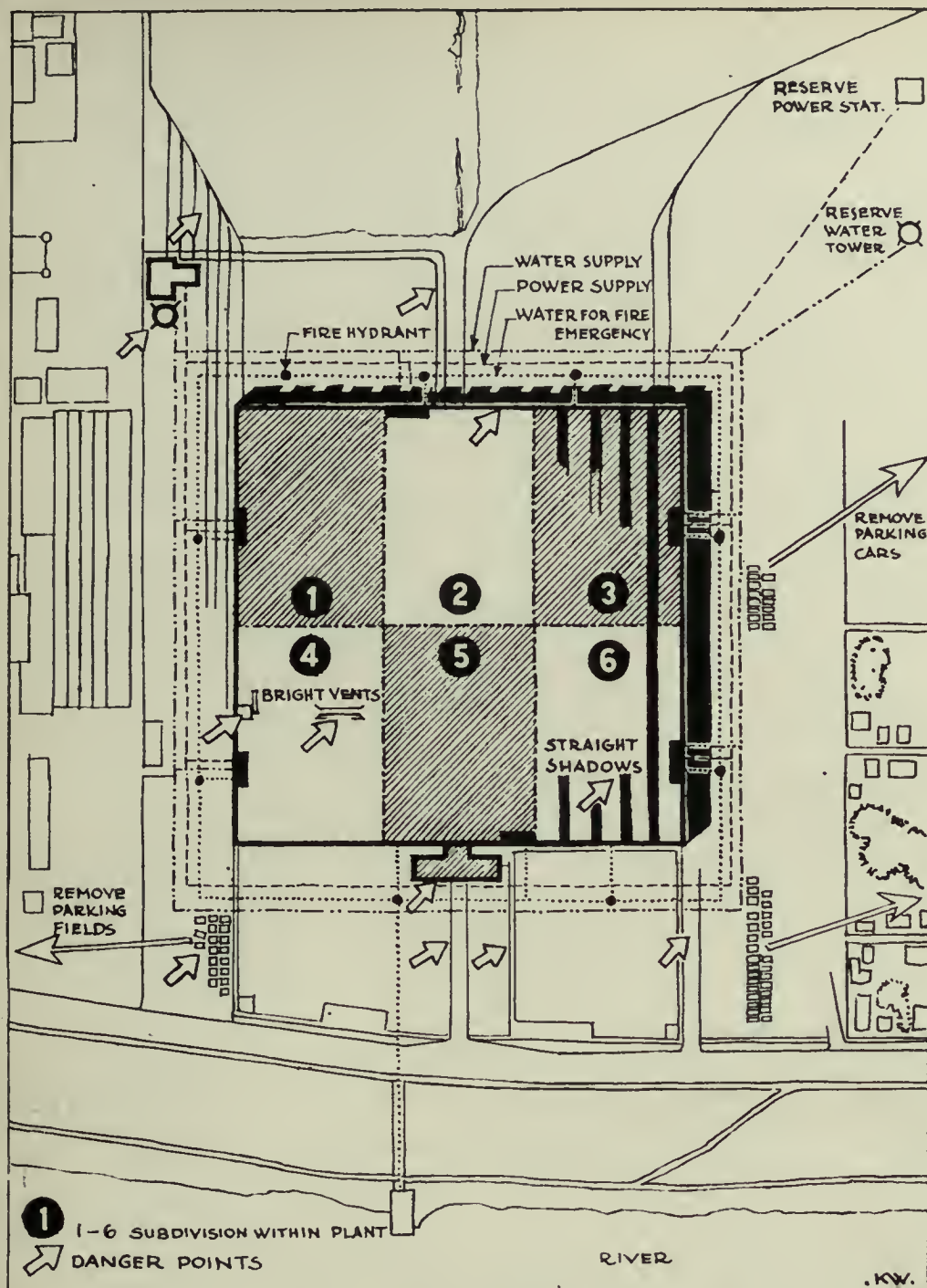
This aerial photograph is used only as an example to demonstrate general requirements of factory concealment and protection.

Analysis of Merits and Demerits:

- 1- The picture shows relative merits of one-story buildings compared with multi-story buildings. The roofs blend relatively well with surrounding landscape.
- 2- Factory is too centralized, i.e. great damage will be incurred by direct hit.
- 3- Access to plant from three sides is good, but roads and parking areas are too conspicuous. Whole area around factory is devoid of trees.
- 4- Location near river helps to locate the plant from the air, but additional water supply from the river is an advantage for fire-fighting.
- 5- Power station and water tower are at some distance from plant, which is good, but they are bright and tall and therefore easily detected.
- 6- Extension is possible without overcrowding the area. Office building is separate although not far enough distant from plant.
- 7- Even and straight lines and shadows are very conspicuous.

Sequence of necessary improvements:

- 1- Immediate improvements to reduce visibility and reflections.
 - a. Darken white driveways and walks and parking areas.
 - b. Decentralize parking cars to avoid long, conspicuous rows of cars.
 - c. Darken the white vents and other pipes on roof and the shining water tank.
 - d. Avoid regularity in mowing lawn
- 2- Immediate improvements to reduce vulnerability.
 - a. Subdivision of plant and plant installations to localize damage.
 - b. Extended installations of supply lines to secure supply after bombardment.
 - c. Extension of water supply for fire fighting.
 - d. Additional power station or connection with power station of other factory.
- 3- Protection of workmen and machinery under aerial bombardment.
 - a. Decentralized shelter buildings for workmen, valuable machinery, blueprints.
 - b. Emergency exits -- Duplicates of vital tools and blueprints in safe places.
- 4- Camouflage of plant to blend with surrounding landscape.
 - a. Irregular slabs on roof, dazzle painting and use of nets.
 - b. Special roof over railroad siding and parked cars.
 - c. Avoid smoke from vents or smoke stacks with artificial draft.
- 5- Provision for future improvement to secure better natural protection and easier camouflage.
 - a. Planting of trees in irregular groups around factories. /camouflage.
 - b. Eliminate smoke stacks and give better protection to water tower.
- 6- Planning for future additions and for the relationship of plant to adjacent residential sections and other plants.



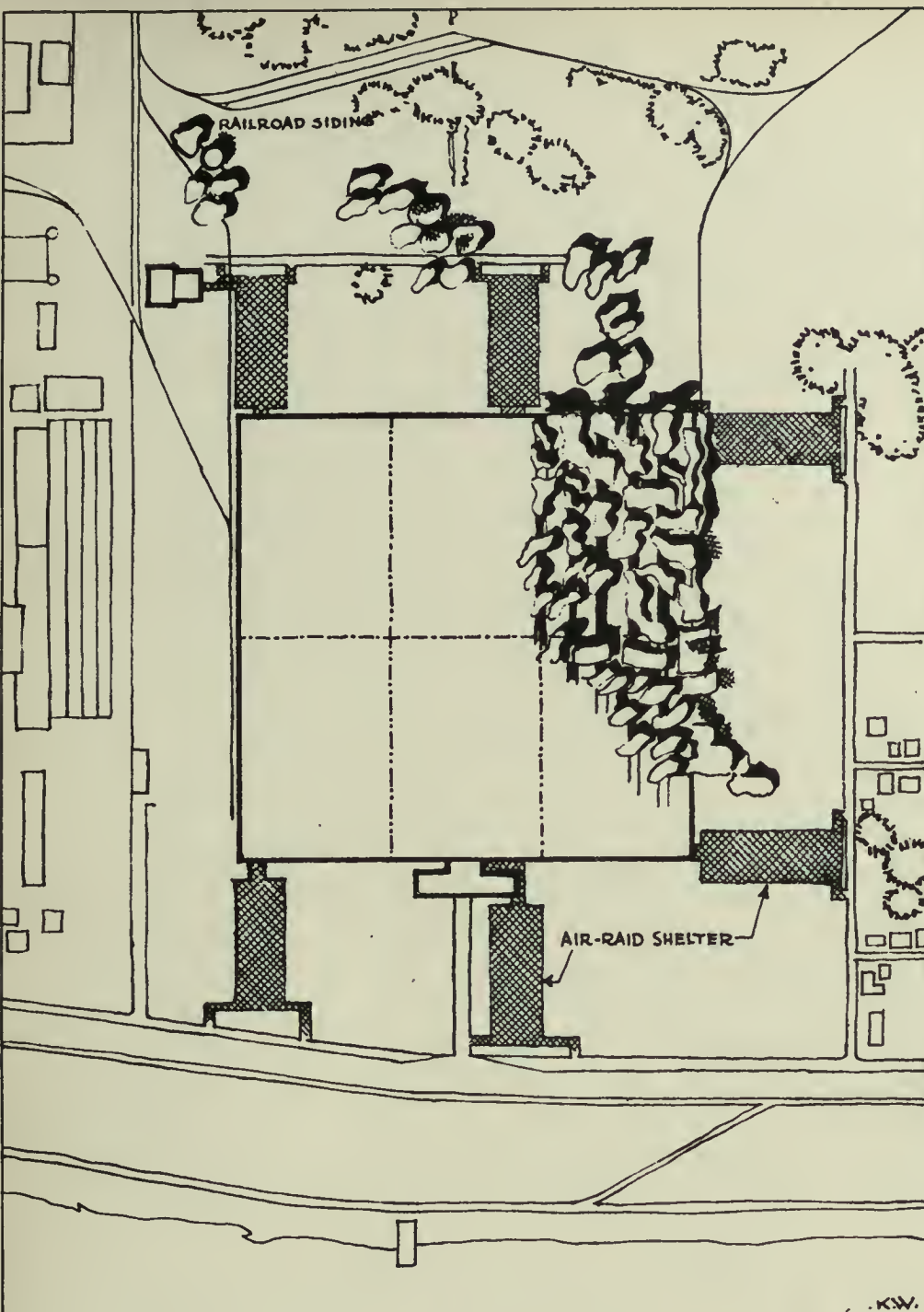
Existing utilities have to be checked and eventually doubled to assure uninterrupted supply if some of the main lines are damaged.

Parking fields will have to be removed and parking decentralized as long as protective landscaping is impossible or ineffective.

Before anything else can be done, a general check-up has to be made from an aeroplane and by means of aerial photography, to detect the objectionable points which might be used by the flier as a guide or as a mark for his bombardment. Ground observation is not sufficient to reveal weak points, and aerial observation should be made under varying light conditions.

To reduce visibility at long distances, all reflections (of roofs, windows, tanks, etc.) should be eliminated.

A general check-up of all plant buildings and installations including machinery and utilities must be made to investigate how every structure and every detail would be affected by aerial attack or force of explosions. Large buildings should be divided into several units, as subdivision within the buildings, with separate switches and supply lines for each unit operating individually.



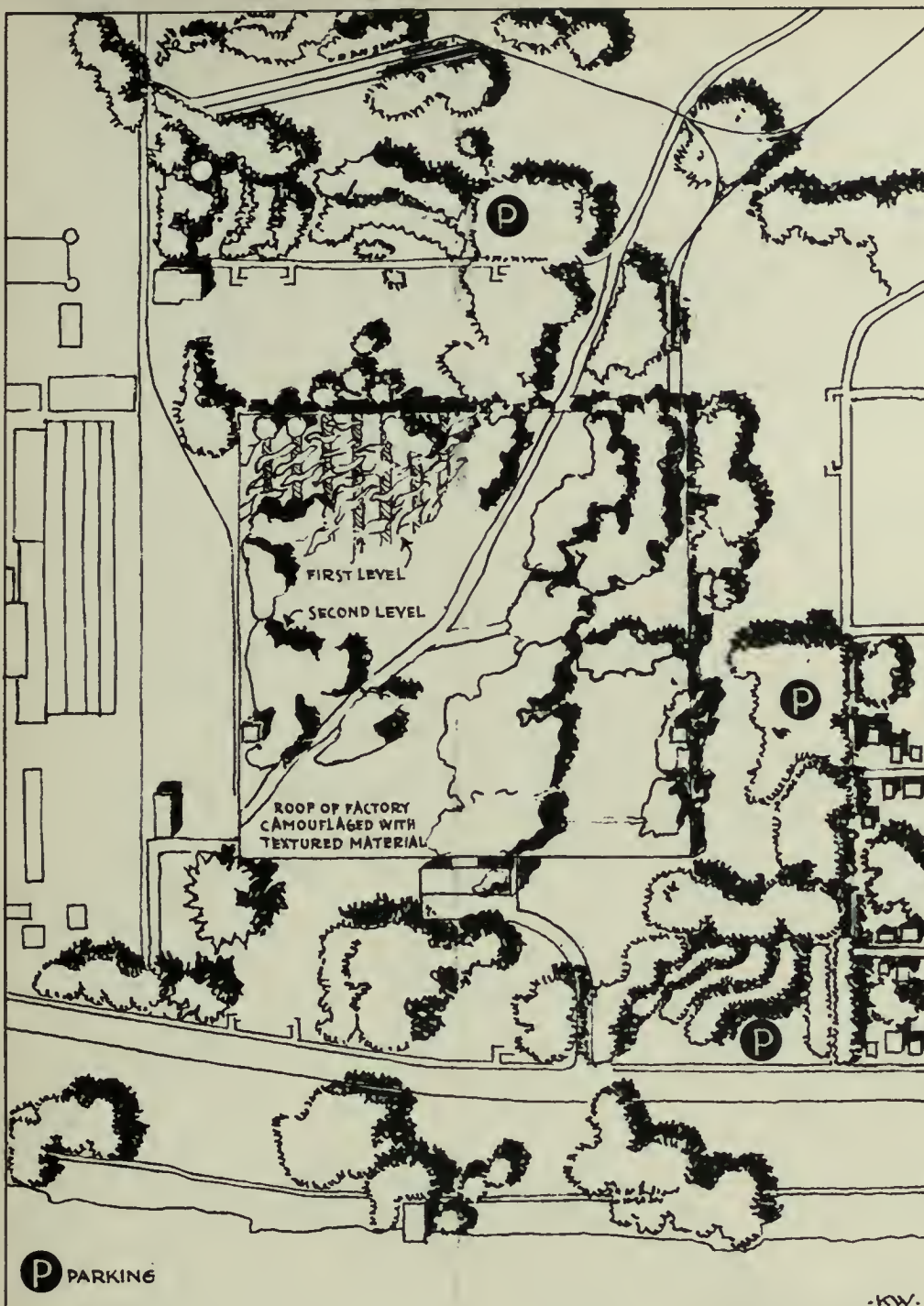
Air - raid shelters should be decentralized also, with exits on opposite corners, preferably leading to parking fields to guarantee quick dispersion of workmen in different directions.

Camouflage of roofs by adopting the texture of adjacent terrain, and without use of trees as long as there are no trees in the surrounding area. Nets spanned to cover shadow and to break up long lines of windows.

This subdivision applies to workmen as well as installations. Shelters for workmen should be in sufficient numbers, preferably separate for each separate unit - not so big as to make supervision difficult, not so small as to cause overcrowding. Exits from shelter to parking fields or onto streets is valuable.

Accessibility of all factory buildings has to be checked; connecting links between roads or railroads considered, and conspicuous tracks or railroad sidings removed to a safer place, away from the factory proper.

A scheme for camouflage under present conditions of surroundings and according to season has to be marked out. These propositions have to consider: 1- Immediate concealment with the best available materials, and 2- Long-range planning of camouflage to make better concealment in the future possible.



Railroad sidings removed from plant and so placed that tracks are inconspicuous and not parallel to lines of plant.

The landscaping with trees should be in harmony with surrounding landscape, favoring fast-growing and tall trees.

Planning for lasting improvements has to consider not only the factory itself, but its relation to the surroundings---to nearby streets, railroads, and bridges, to other factories, and to general features of the landscape. Gradual removal of dangerous points, elimination of bottlenecks, replacement of unfit buildings, safer arrangement of supply lines, underground placement of tanks characterize this stage of improvements. An extensive tree-planting program can help to restore the original features of the landscape and to make future camouflage easier.

The practical and, at the same time, less obvious arrangement of parking fields is a very important, and, until now, mostly neglected task for landscape architects. The tree-planting program is ineffective unless projected on a wide scale, as part of a program for the entire industrial area.

SUCCESSIVE STEPS OF FACTORY IMPROVEMENT AND PREPARATION FOR AERIAL SAFETY

5

BUILDINGS

ROADS AND COMMUNICATIONS

UTILITIES

WORKMEN AND EQUIPMENT

CAMOUFLAGE

I. Preparatory Planning and Experimental Research

Checking safety of constructions under stress of explosions.

Checking exits and staircases.

Study of repair facilities.

Removal of shacks. Clearing of garrets. Fire-proofing of roofs.

Provisions to reduce smoke.

Installation of fire - fighting equipment.

Checking visibility of roads.

Organization and dispersion of parking fields.

Planting program for parking areas.

Connections with highways. Safety of bridges or tunnels.

Accessibility of all structures.

Planning by-roads.

Planning underground connections between buildings.

Checking depth and ground coverage of gas and water mains and cables.

Study of distribution of valves and accessibility of mains.

Plan for extension of supply lines and use of natural water resources.

Improving switch facilities for electricity, telephone, signal apparatus.

Checking vulnerability of water towers.

Study of vulnerability of valuable machinery.

Study of repair facilities and domestic materials.

Principal planning for air shelters.

Training in first aid, fire fighting bomb fighting.

Reserve machinery. Reserve tools. Reserve buildings.

Duplicating blue-prints and files

Aerial observations and photographs.

Checking visibility and dangerous reflections.

Design, preparation and storage of camouflage materials.

Practical experiments with camouflage material.

Testing blackout materials.

Painting for protective coloration.

II. Actual Building in Emergency

Protective structures over windows and exits. Reduction of glass area.

Reinforcing existing constructions.

Remodeling buildings to improve safety.

Removal of chimney stacks.

Elimination of bottlenecks of roads and railroads.

Removal of railroad sidings. Removal of conspicuous streets.

Elimination of parking areas.

Protection of mains. Installation of switches.

Reserve lighting and signal system.

Additional supply buildings. Subdivisions and interconnections.

Pump works.

Building shelter and facilities for quick dispersion of workmen.

Elimination of dangerous congestion.

Protective roofs and shelter for machinery.

Actual camouflage and blackout installations.

Dimming or elimination of reflections.

Elimination of smoke. Reduction of light.

Dummy buildings.

III. Long Range Planning and City Planning Aspects (Industrial Areas as Defense Units)

Planning factories under higher safety standards.

Developing less vulnerable building types.

Improved and increased road systems.

Separation of residential and industrial areas.

Better general planning and distribution program

Subdivision of supply facilities.

Collaboration with neighboring factories.

Creating open spaces around dangerous buildings.

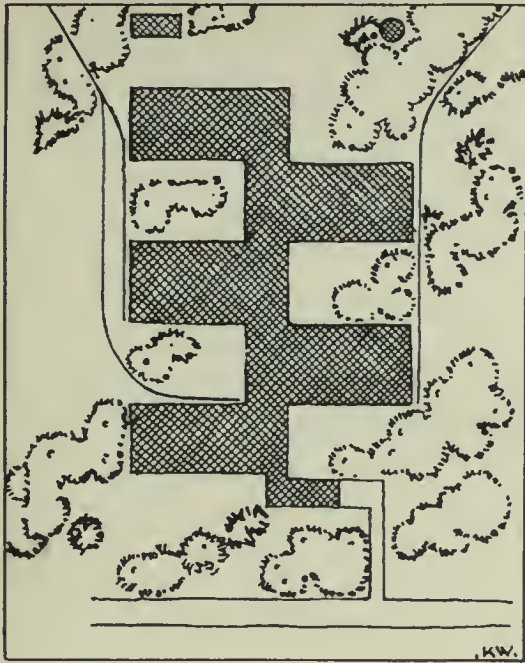
Collaboration program for mutual help.

Increased care for workmen safety.

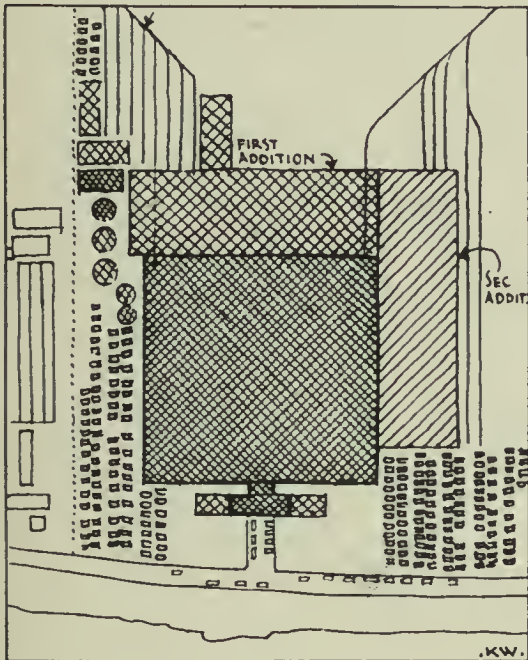
Use of domestic materials and labor.

Conservation of natural formation of landscape.

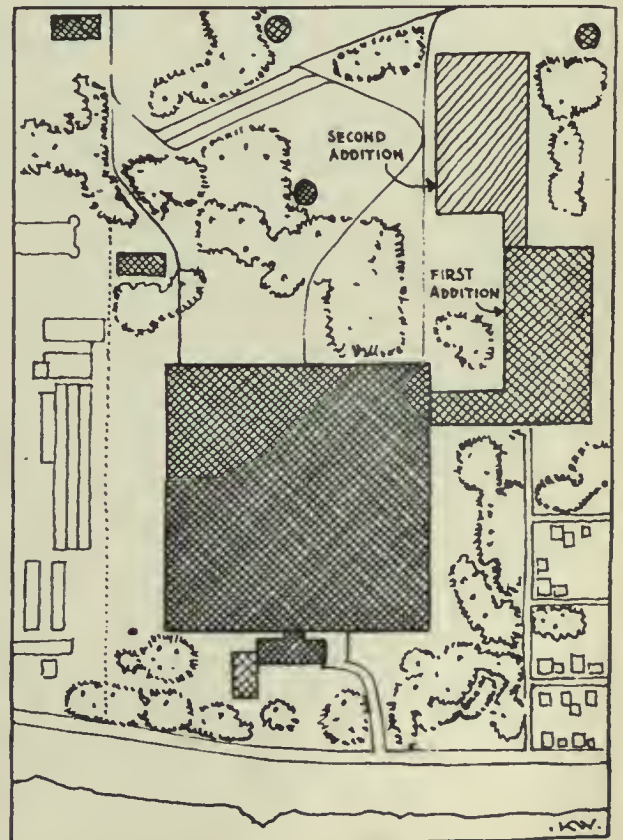
Planting program for future better camouflage.



The ideal scheme for an air-worthy factory avoids buildings that are too large and where all manufacturing processes are huddled under one roof. Subdivision into several smaller units dispersed over a large area, or connected, has the advantage of reduced vulnerability, improved accessibility, and easier repairability. This "open layout" is possible without impairing the assembly line.



Future additions should follow these new principles of design and avoid the present practice of bringing more and more workshops under one roof. This sketch represents dangerous practice in design of factory extensions.



Safe practice of designing new additions produces an open layout with large distances from building to building, and separate supply installations. A state of maximum ground coverage should be established for each factory to avoid dangerous congestion.

INDUSTRIAL CAMOUFLAGE

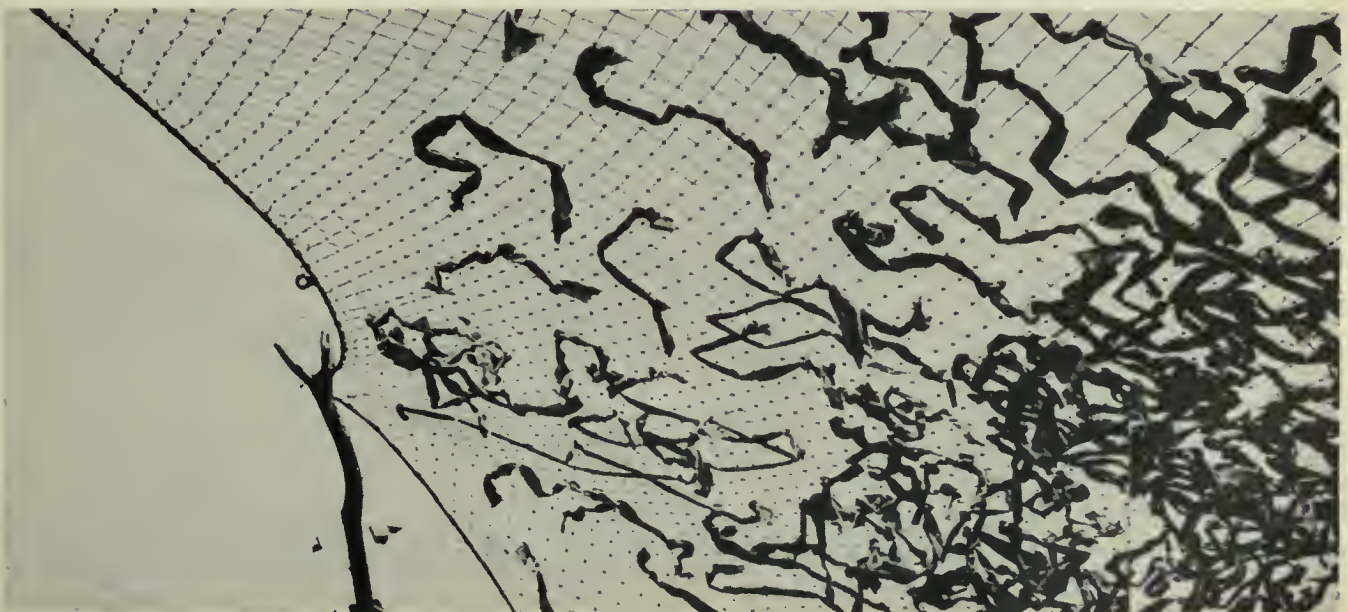
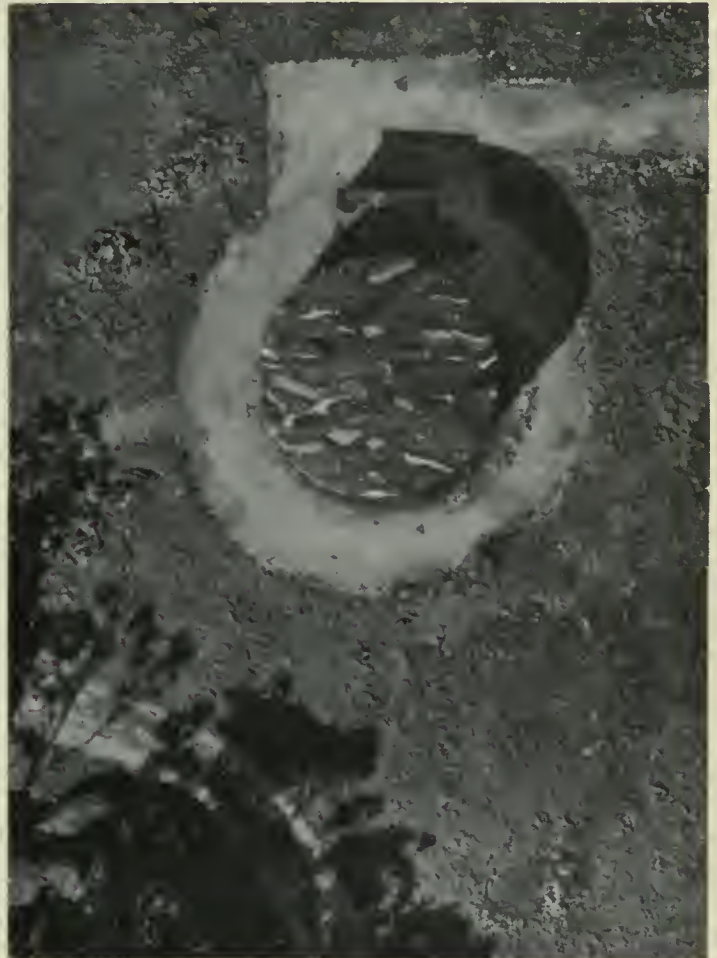
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PART II - INDUSTRIAL CAMOUFLAGE PRINCIPLES, METHODS, AND MATERIALS

Successful camouflage is never the result of tricks or mystification. Study of nature, repeated observation, and an ability to "build" three-dimensional effects are necessary premises for good camouflage work. The art of the painter is two-dimensional. He may, by clever contrasts, deceive the close observer into believing he sees a relief. This illusion does not hold true for 5,000 ft., however. Real shadow is, at great distance, much more effective than any painted shadow. Camouflage has been declared an art, like that of the painter but reversing his principles. This is false; we can not suppress form with paint, nor fight real shadow with painted light. Every observation of nature reveals a composition of light, self-shadow, and cast shadow. An artificial reproduction of nature must compose similar elements - parts which catch light and others which absorb shadow.

The painted tank and the garnished net illustrate the two methods of approach.

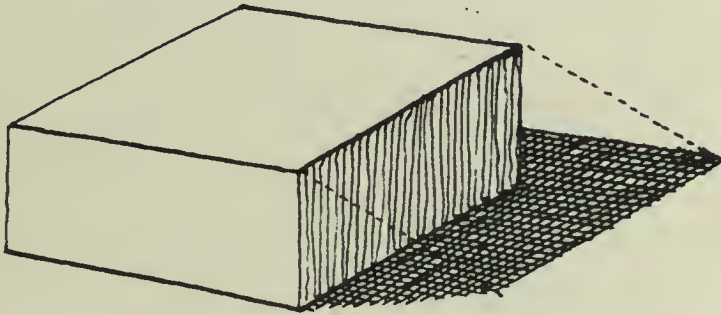


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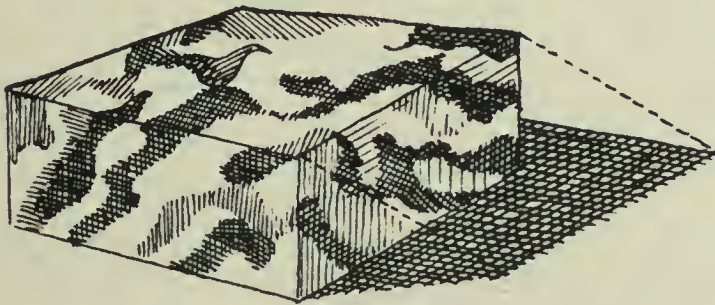
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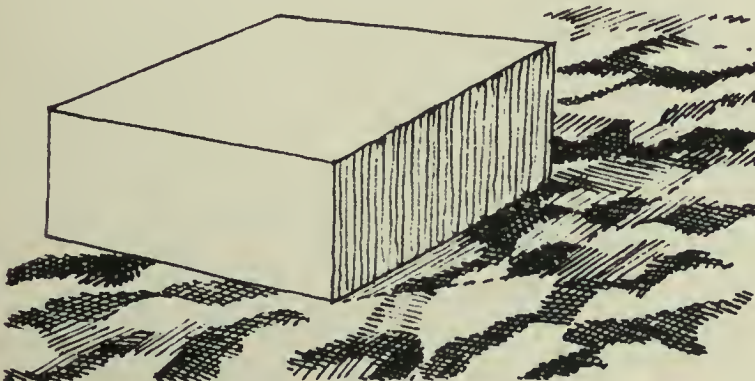
PRINCIPLES OF INDUSTRIAL CAMOUFLAGE Distortion of Forms



Geometrical shapes and straight shadows are easily spotted from the air.



Disruptive design or "dazzle-painting" confuses the perception of form, if the effect of the pattern dominates, e.g. if the pattern has strong contrasts. This will give only limited deception, however; dazzle painting is ineffective if seen from a great height. The straight shadow remains.



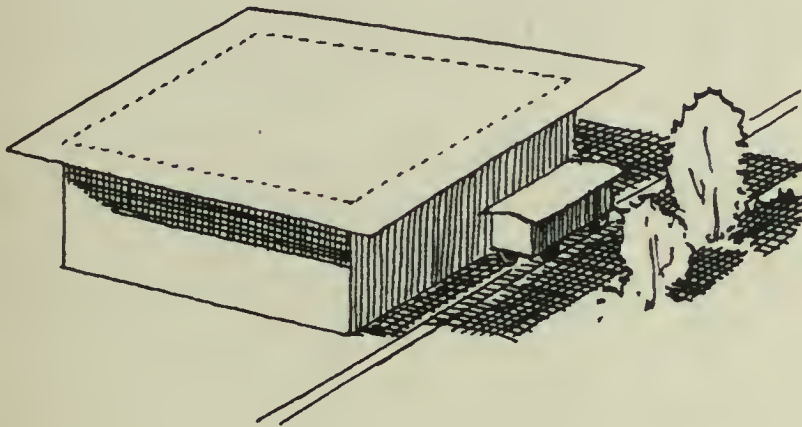
Pavement of dark and white material in irregular pattern can to a certain degree distort the regular shadow.

INDUSTRIAL CAMOUFLAGE

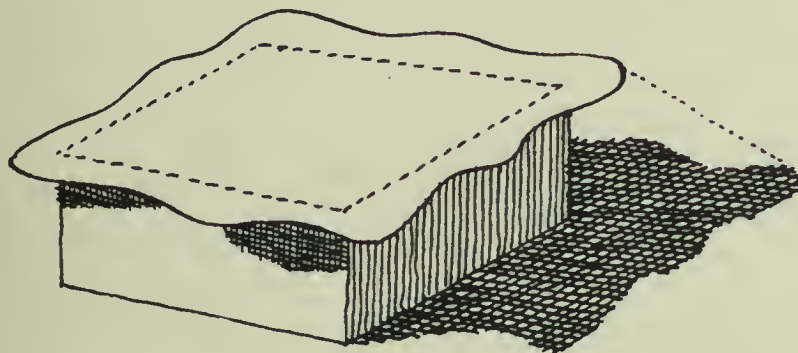
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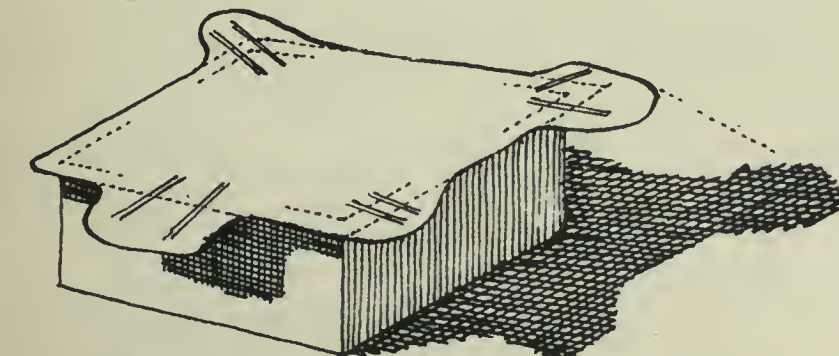
PRINCIPLES OF INDUSTRIAL CAMOUFLAGE Distortion of Shadows



Projecting roofs shadow vertical walls, and cover adjoining white pavement, railroad tracks, loading cars, etc., to prevent visibility from the sky. Surrounding landscape, trees and shrubs, can be brought nearer to distort the shadow.



Roofs with curved shapes distort the rigid geometry of light and shadow.



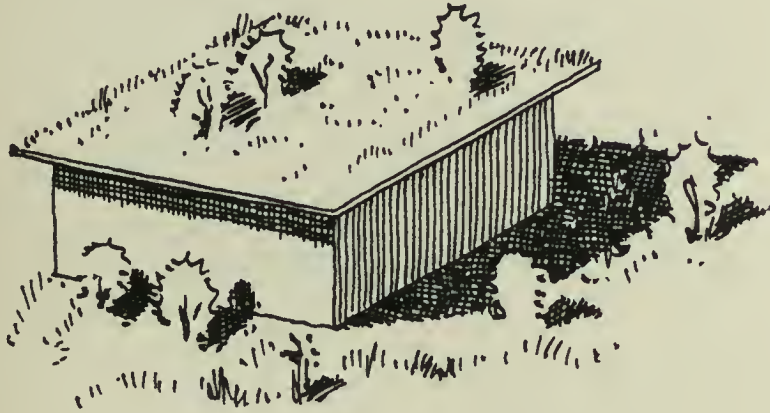
Projecting slabs can be temporarily added in wartime to give distortion of shadow. Such devices have to be changed, from time to time.

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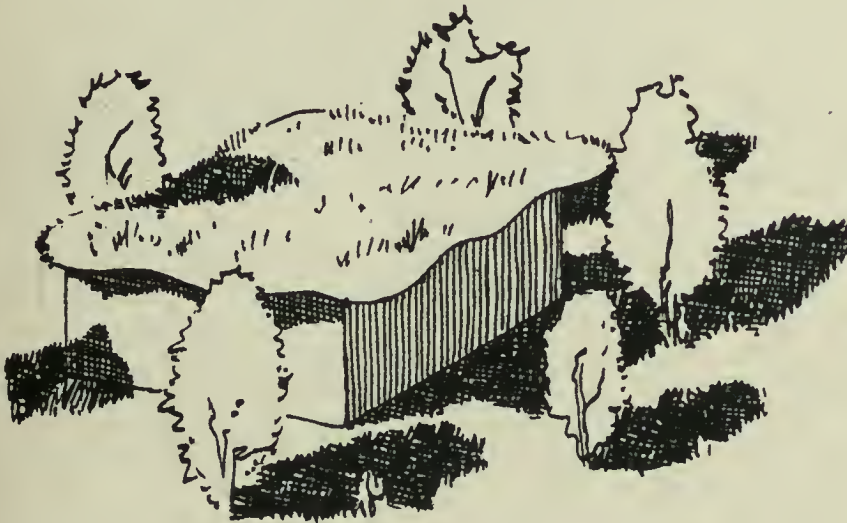
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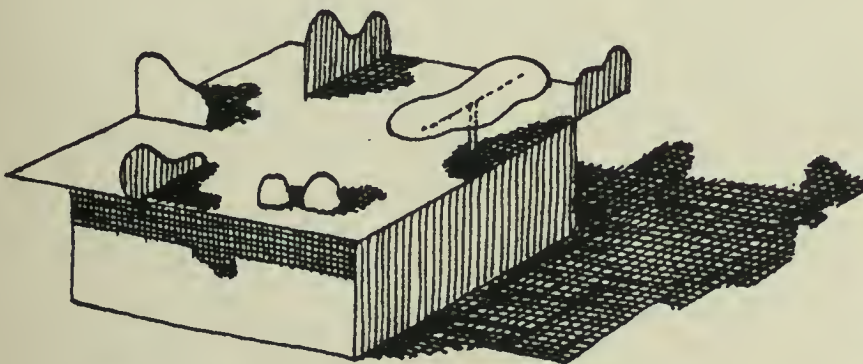
PRINCIPLES OF INDUSTRIAL CAMOUFLAGE Texture of Roofs



Roofs which are planted with grass, or even with small shrubs can match their surroundings almost entirely, under all weather and light conditions.



Surrounding with trees gives better concealment and natural irregularity of light and shadow. Trees play an important part in the design of natural camouflage.



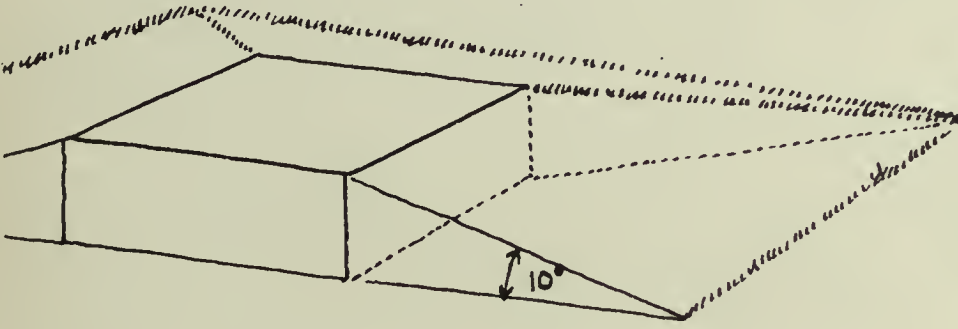
Vertical, irregular slabs, or horizontal slabs, elevated several feet, cast irregular shadows to distort the monotony of large roofs. Gravel, cinders, and stones of lightweight, porous concrete give rough texture.

INDUSTRIAL CAMOUFLAGE

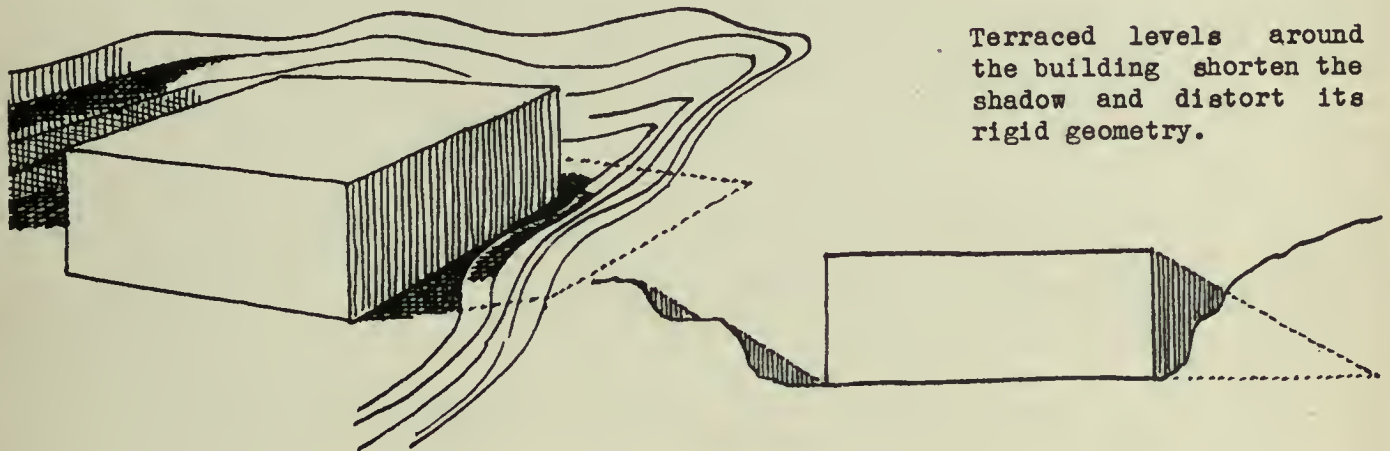
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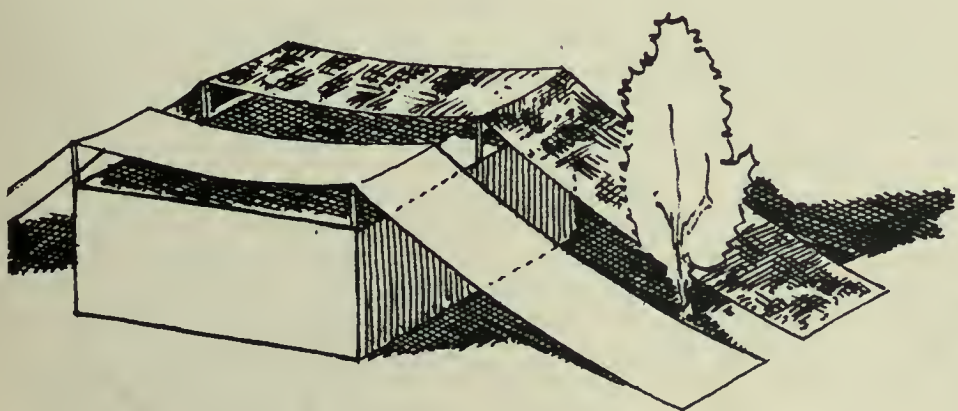
PRINCIPLES OF INDUSTRIAL CAMOUFLAGE Elimination of Shadow



Grading of the terrain at an angle of 10 degrees gives complete elimination of shadows. The object is hardly noticeable from the sky, especially if the texture of the roof matches the surroundings.



Terraced levels around the building shorten the shadow and distort its rigid geometry.



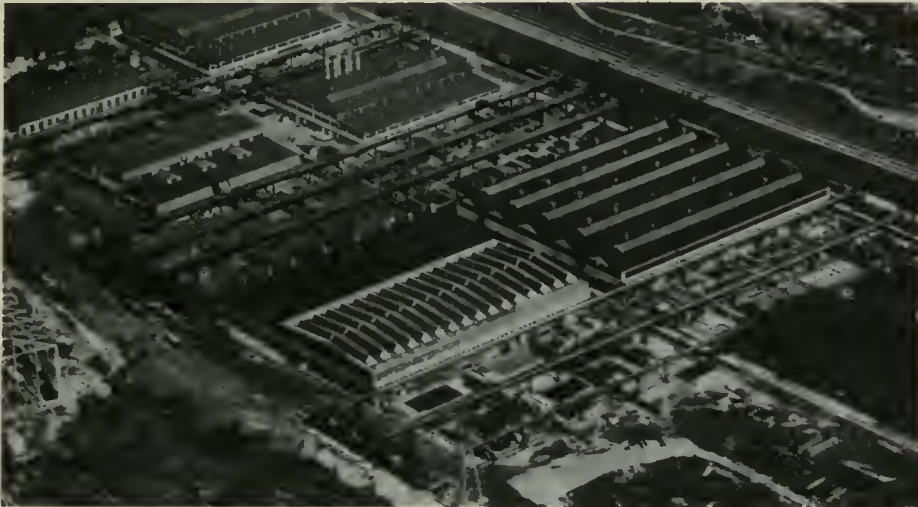
Expanded nets confuse the outlines of light and shadow, and dissolve the geometrical shapes into an irregular pattern of dark and light spots.

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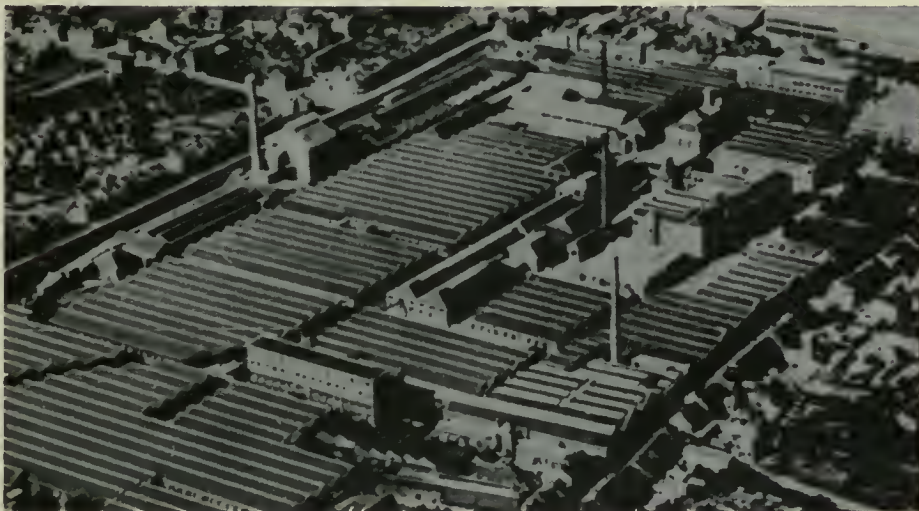
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STUDY AND ANALYSIS OF ROOFS



The bombardier sees his target as a lay-out of roofs, rather than as an architectural ground-plan. A birds-eye plan of the roofs, considering all possible shadows and reflections will therefore be an integral part of future factory design.



Generally, pitched roofs have more reflections than flat roofs and show a more definite pattern. Unpainted metal roofs show most brilliant reflections; it takes a long time for the smooth surface to corrode. Very dark roofing material or roof-coatings are just as conspicuous as very light ones. Half-tone grays are most likely to blend with surroundings.



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UNSUCCESSFUL PATTERN PAINTING



The application of paint, in order to make one form look like an entirely different, less conspicuous form, is very limited in its effectiveness where applied to large buildings. The Theory of Disruptive Patterns, as stated in books on protective coloration of animals, has led to several misconceptions.

Again and again, we see camouflage suggestions published which are only painted tricks on models, without any practical value. The truth of this is demonstrated by three pictures.



A big tank is standing among rows of houses. The dark roofs and gray elevations of the houses, and the white pavements are painted so skillfully on this tank that the vertical and horizontal lines and the values give the effect of a row of houses.



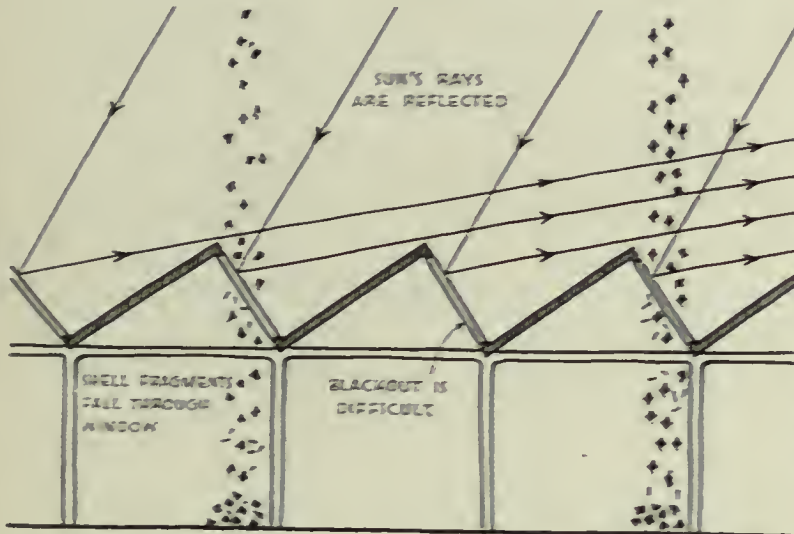
This holds true, however, only for one definite point of observation and for just one position of the light with stationary shadows. As soon as the light changes, or when the observer changes his position, the illusion is apparent. The tank stands out, even more conspicuous than before.

INDUSTRIAL CAMOUFLAGE

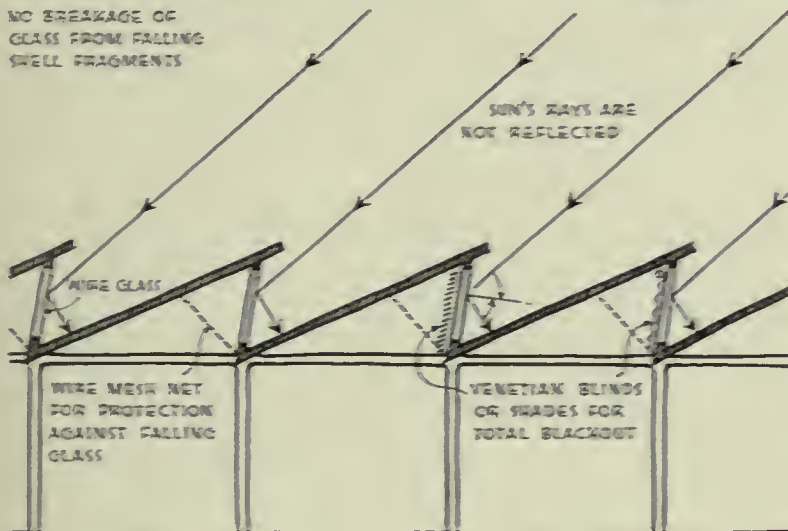
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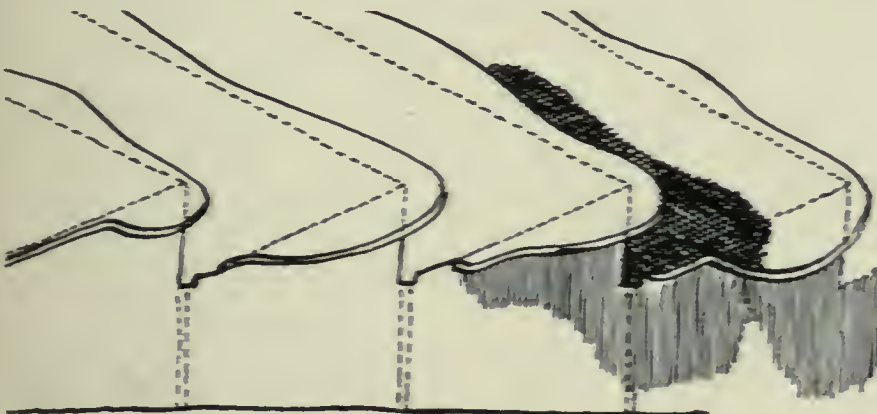
SUGGESTIONS FOR INDUSTRIAL CAMOUFLAGE DESIGN Vulnerability of Sawtooth Roofs



Saw-tooth roofs are essential for many types of factories. They have been built until now in different systems but all follow the same principle. These roofs reflect the sun's rays at great distance and form an easy guide for the airplane. Shell fragments fall through windows, and blackout is difficult.



This is a new type of saw-tooth roof which avoids, through the inclined position of the glass, the reflection of the sun's rays. Wider projections protect the windows. No breakage of glass from falling shell fragments. Blackout is easy.



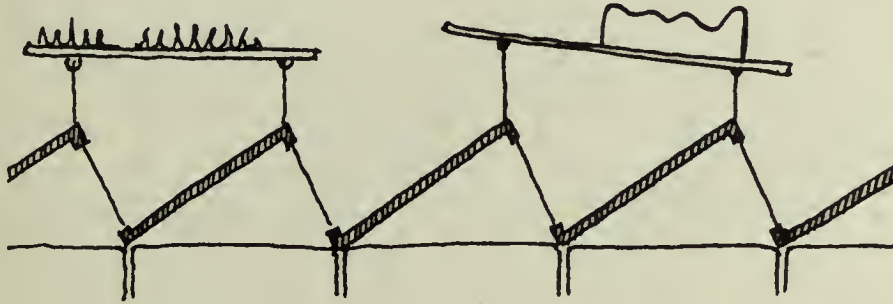
These projections can be designed in serpentine shapes to distort the straight shadows of parallel lines. Projections of the side of the building distort the characteristic form of the elevation.

INDUSTRIAL CAMOUFLAGE

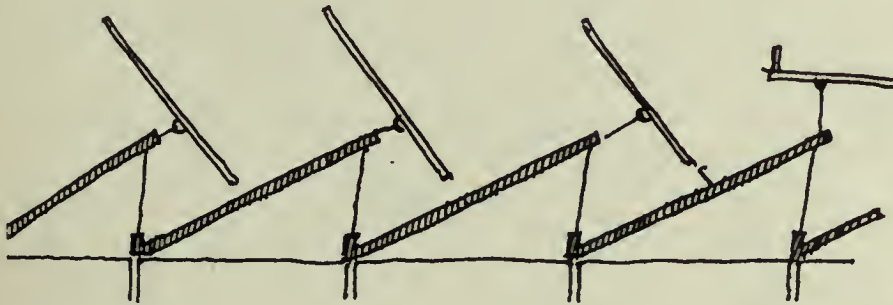
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SUGGESTIONS FOR INDUSTRIAL CAMOUFLAGE DESIGN Sawtooth Roofs

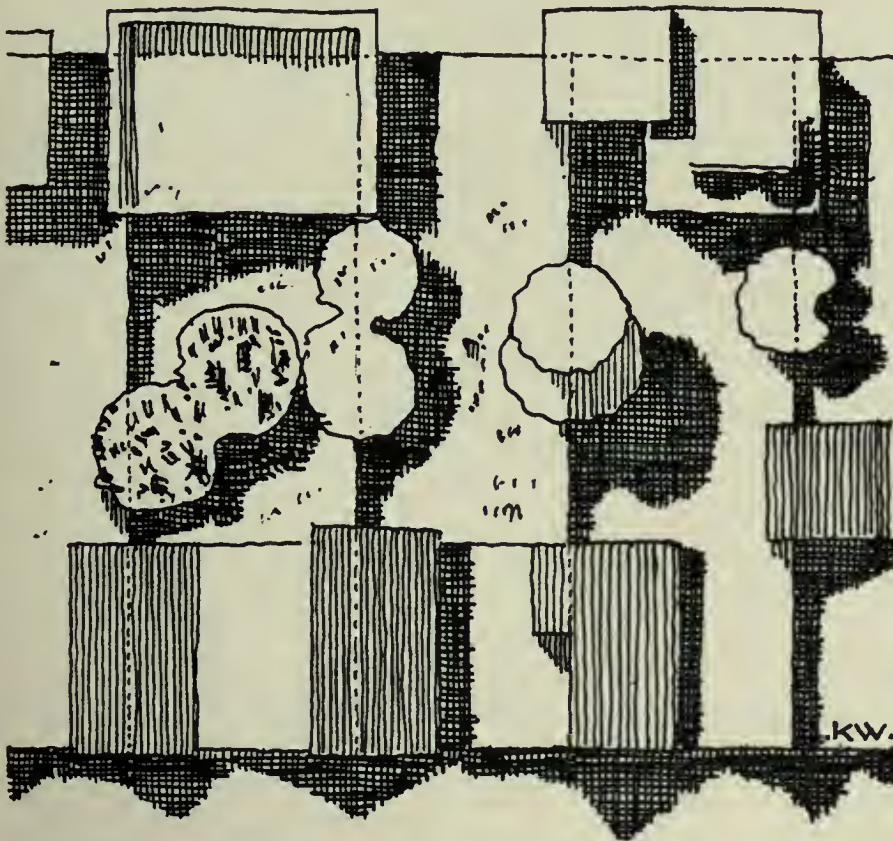


Camouflage of saw-tooth roof of older type, with horizontal slabs placed several feet above the roof, and at different angles to the roof.



Saw-tooth roof of newer type with protected, non-reflecting windows. Slabs are placed to simulate small homes.

By use of this method, the reduction of light is at a minimum.



Aerial view of camouflaged saw-tooth roof.

Application of slabs of different sizes, shapes, and textures, to give the appearance of small homes with flat and pitched roofs, trees, and back yards.

Solid constructions are, as a rule, brought down to existing supports or bearing walls. Sectional scaffolding may be used to cover wider spans. The construction should be movable in order to facilitate adjustments during the course of the year.

INDUSTRIAL CAMOUFLAGE

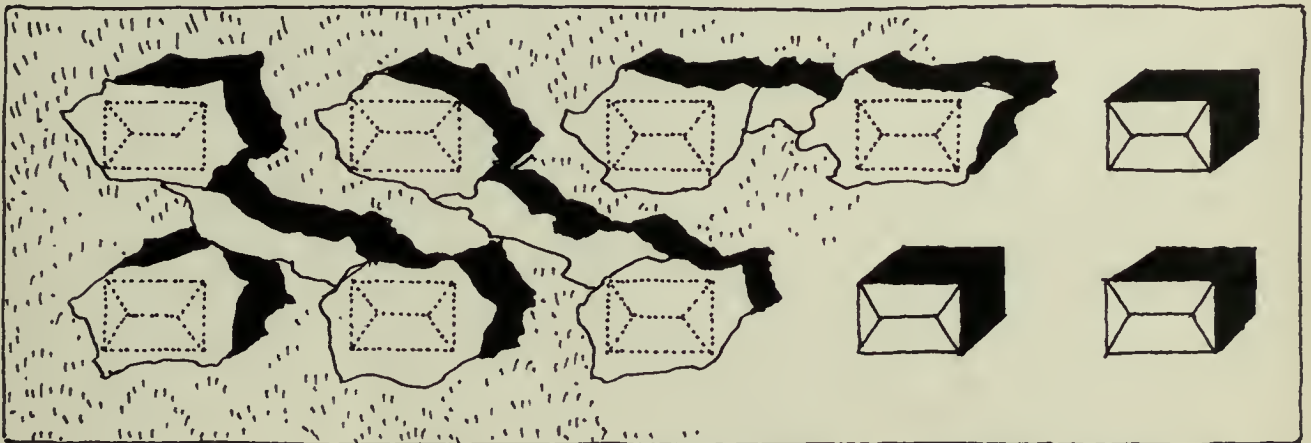
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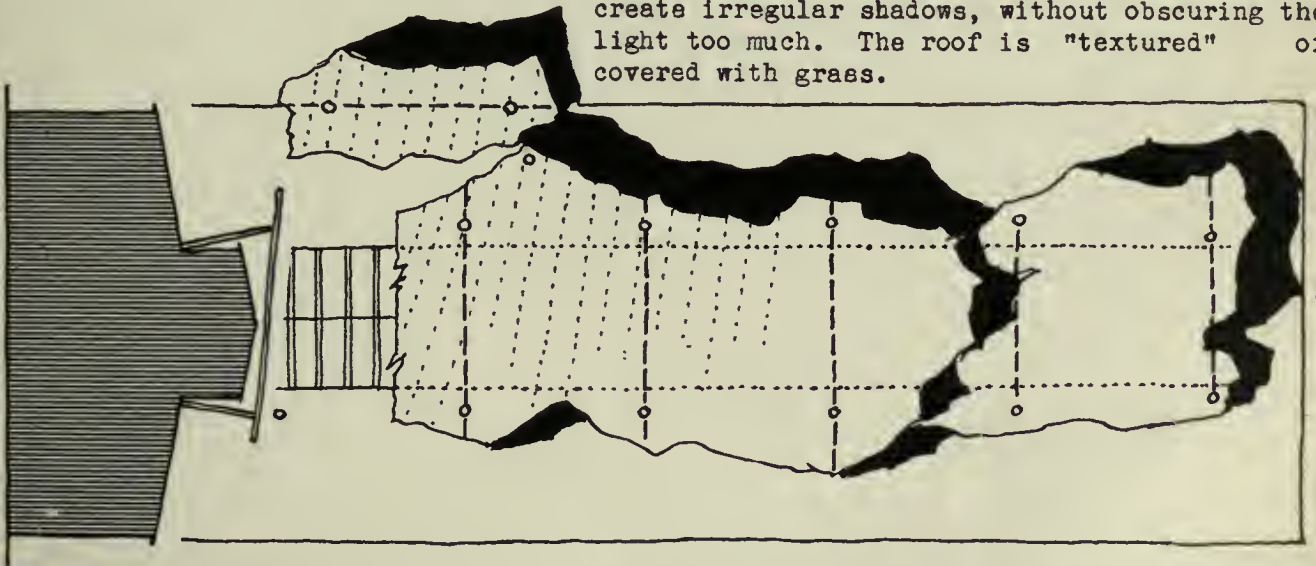
SUGGESTIONS FOR INDUSTRIAL CAMOUFLAGE DESIGN Camouflage of Skylights



The regularity of rows of skylights with reflections and marked shadows renders skylighted roofs very conspicuous.



Superstructures of irregularly-shaped boards on four or more poles cover the reflections and create irregular shadows, without obscuring the light too much. The roof is "textured" or covered with grass.



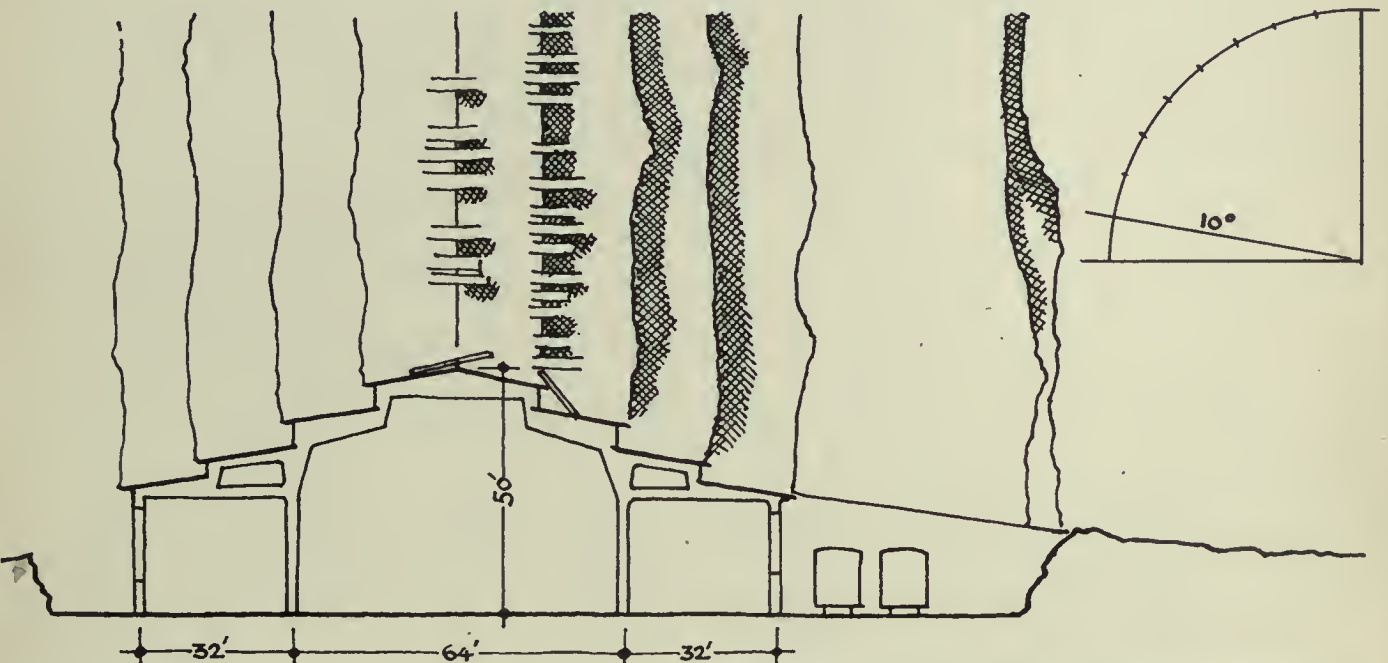
A long skylight might be treated similarly. The superstructure is supported by sectional scaffolds of trussed end-frames; it may be built in sections and sloped at various angles.

INDUSTRIAL CAMOUFLAGE

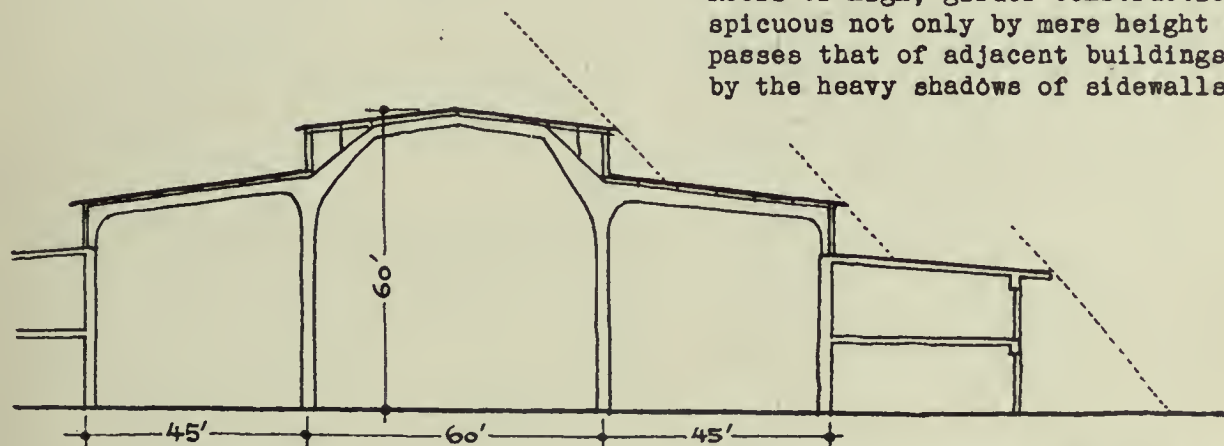
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SUGGESTIONS FOR INDUSTRIAL CAMOUFLAGE DESIGN High Roof Constructions

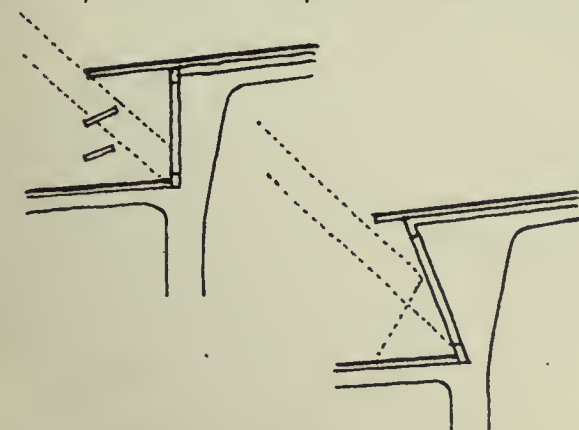


Roofs of high, girder construction are conspicuous not only by mere height which surpasses that of adjacent buildings, but also by the heavy shadows of sidewalls.



This conspicuousness may be eliminated by gradually stepping down from the ridge to a normal height, sloping the roofs at an angle of approximately 10° . The edges of these roofs can have irregular shapes, or boards can be used temporarily in order to further confuse the remaining, relatively unimportant shadow-lines.

High, reflecting windows are thus replaced by several relatively low windows, set back into the shadow of the eaves. These windows do not give any dangerous reflection, and they are easily blacked out.



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SHADOW STUDIES UNDER THE SUN MACHINE



These three pictures give the shadows for the latitude of New York on the 15th of February, 1942: at 9 a.m.(above), 12 noon (right), and 3 p.m.(below).

Camouflage models are studied under the sun-machine to check the efficiency of the camouflage design. The suggested scheme may be good for the high-standing sun at noon, but wrong for early morning or late afternoon hours, when shadows are considerably longer.



The sun-machine should be so constructed as to permit calibration for every day of the year, and every longitude and latitude of the globe.

Vertical or oblique pictures can then be taken for any suggested angle of recognition.



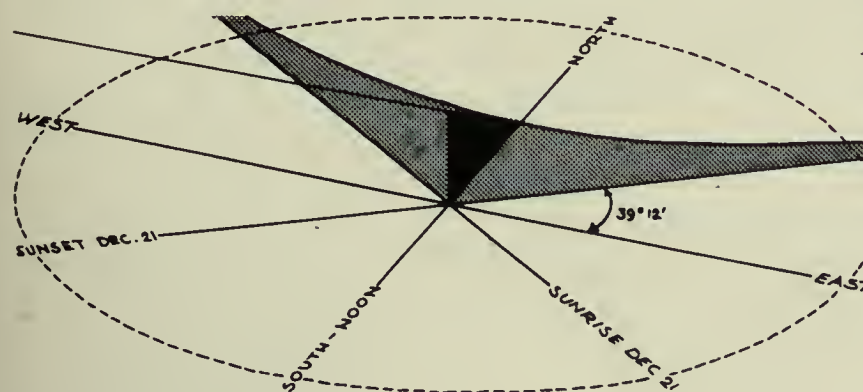
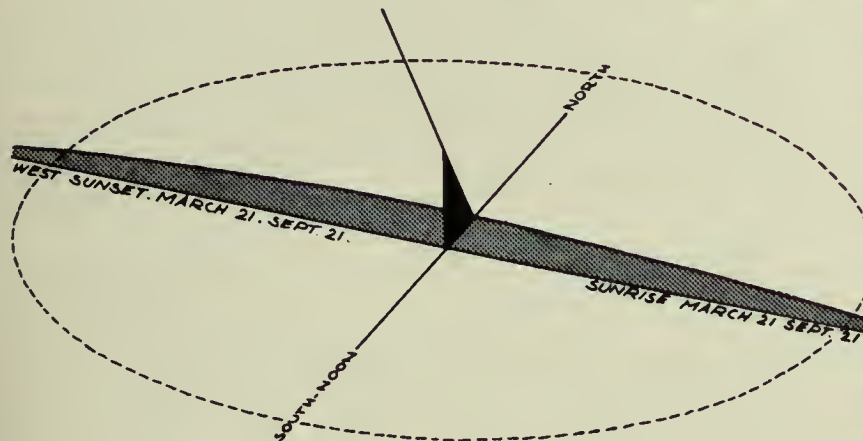
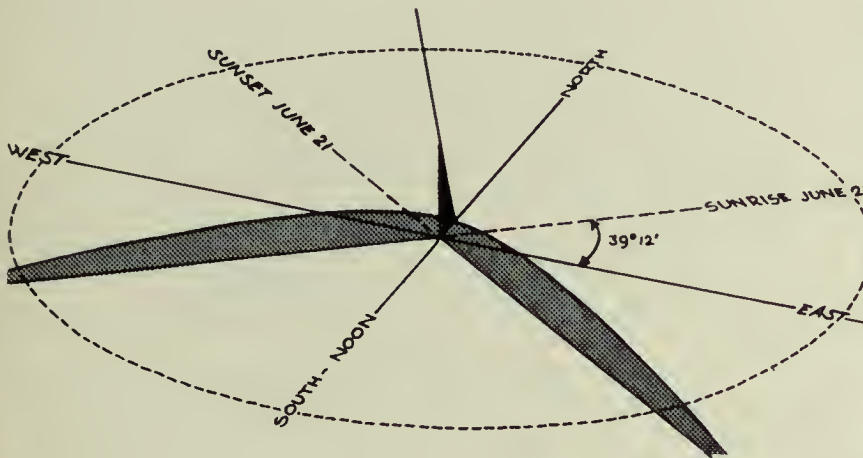
Part of the model shows camouflaged buildings, stylized for demonstration.

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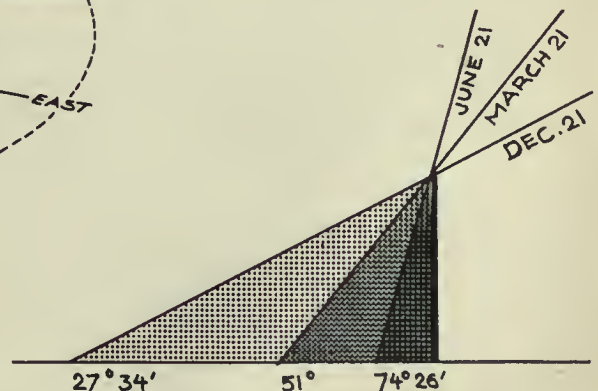
SUN'S DIURNAL PATH - THE SHADOW SECTOR



Vertical aerial survey pictures show a shadow pattern which reveals the relief of the object. This shadow pattern changes from hour to hour and from day to day. If the day and hour of the exposure and the latitude of the place is known, it is possible to compute the height of the structure.

Reciprocally, it is important to eliminate shadows in order to render a building less conspicuous. The camouflage construction should be extended far enough to cover the whole shadowed area. The area which is covered by shadow during a certain period is called the shadow sector. Note the difference in the sectors of June and December. The shadow of a chimney in Iceland is entirely different from the shadow of a similar chimney in Burma or Hawaii.

Therefore a camouflage construction designed for shadow elimination in June is wrong in December. Sometimes camouflage protection is necessary only for a definite, limited time (where action is expected); sometimes as a year-round protection. To save cost and material, the camouflage area should be closely adapted to time and shadow.



Altitude for Washington, D. C.

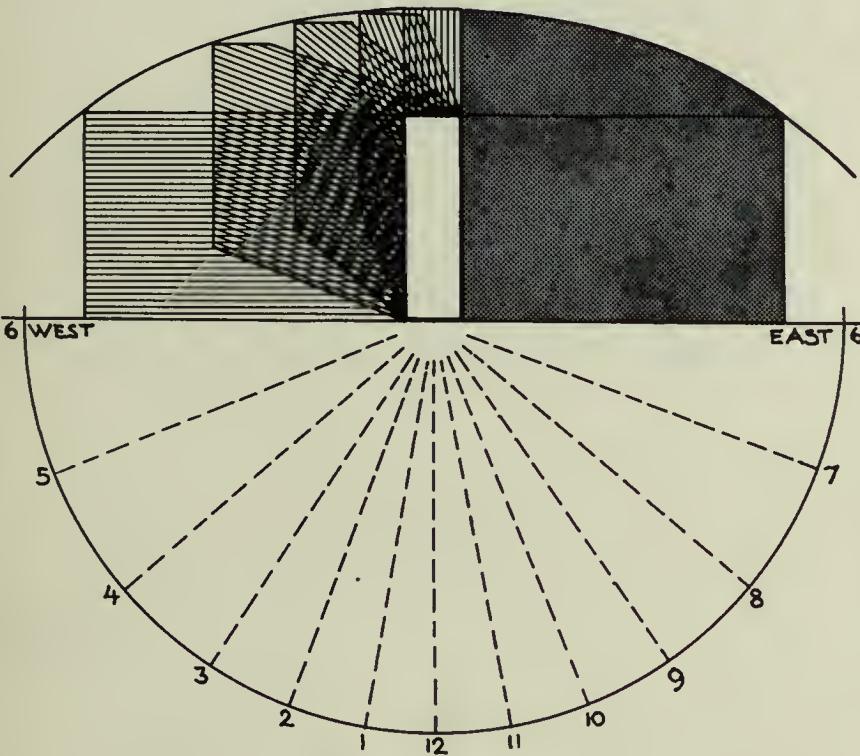
Date	Sun's Declination	Altitude (noon)
Mar. 21-Sept. 21	0°07'	51°
June 21	+23°26'	74°26'
December 21	-23°26'	27°34'

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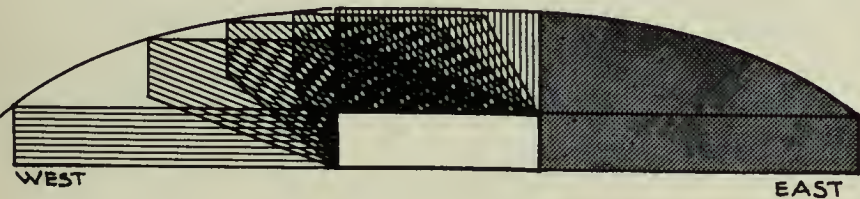
SHADOW'S DIURNAL PATH - ORIENTATION OF BUILDINGS



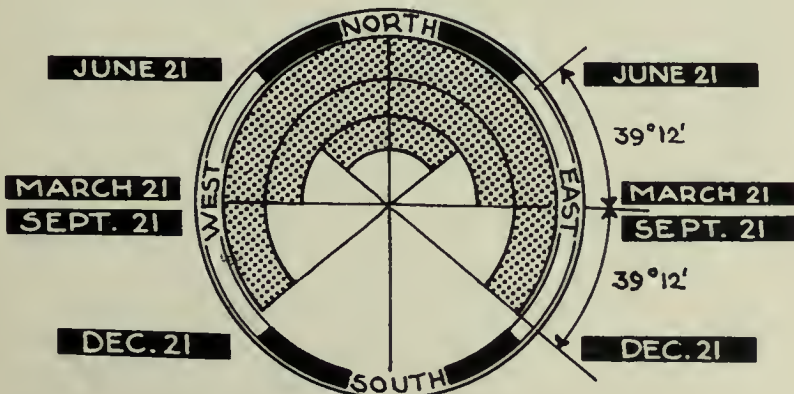
Avoidance of conspicuous shadows and reduction of the shadow area are chief requirements of air-protective planning. Buildings are surrounded by trees or placed at the edge of a wood so that their shadow, in an aerial view falls under trees. Permanent buildings need all-year considerations.

The orientation of buildings is important. Long buildings in East-West orientation have a minimum shadow area, while those in North-South direction have a maximum shadow area. East-West orientation reduces the long morning and afternoon shadows.

This chart demonstrates the comparative shadow areas, from 6 a.m. to 6 p.m.



A combination of several factors (orientation, design of roofs, relief of terrain, contoural features on ground, shadow pattern of plants) may be most effective.



The area which is reached by shadow is almost three times as large in June as it is in December. Morning and late afternoon hours are most critical for artificial installations because the low sun brings out fine details which are less conspicuous under a high sun at noon.

The illustration gives the angular distance of sun's rising and setting from the East-West axis for Washington D. C. (latitude $38^{\circ}56'$ North).

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PART I - NEW ASPECTS, NEW REQUIREMENTS, NEW PROGRAMS



Every aerial view reveals the story of the origin and growth of the American town. Cities were planned as two-dimensional design - a layout of streets, highways, sidewalks, gas mains, water mains, and sewers, cutting straight lines into the virgin face of the landscape. Sometimes the gridiron of streets was groping along the low ground of valleys only, sometimes it covered plains and hills as a continuous pattern. Railroads and railroad sidings came later; docks, bridges, and factories dotted the rural countryside with far-visible landmarks.

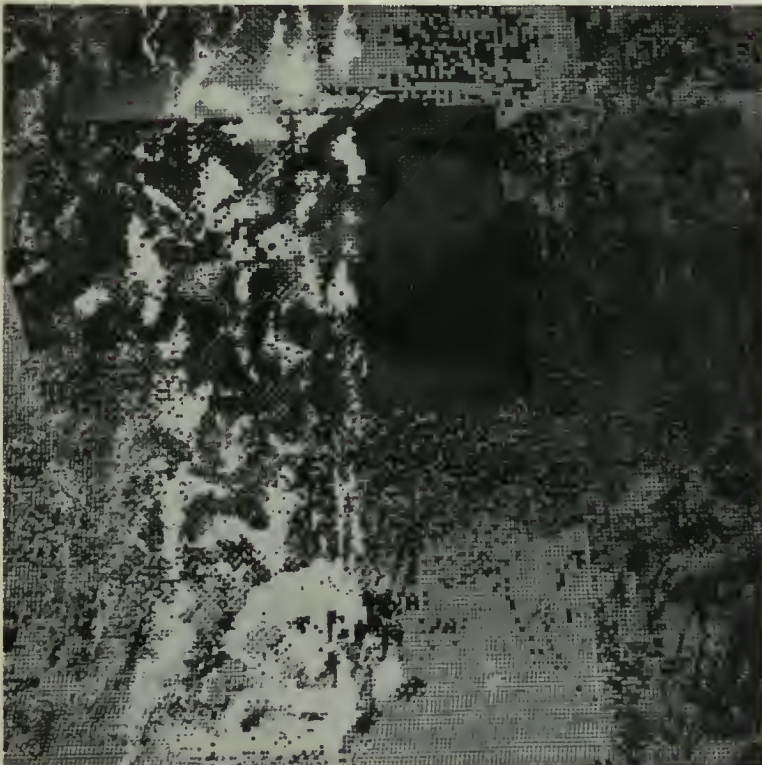
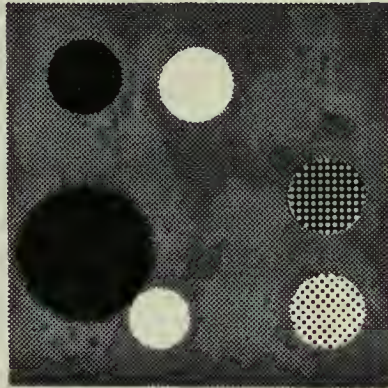
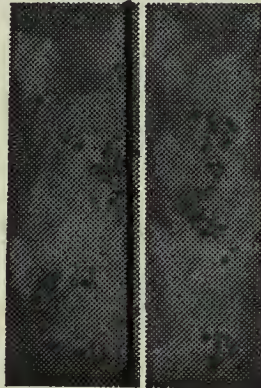
This gay and revealing picture assumes new meaning under the threat of aerial warfare. We study possible lines of approach along rivers which cannot be "blackened out" - along highways and railroads. We check the vulnerability of bridges; we discover the dangerous neighborhood of target areas and landmarks. A new element determines our planning - the bird's-eye view. Until now, we designed a factory with ground-plan and elevation, but it is no longer unimportant how this looks from the sky.

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VISUAL PROBLEMS



Study of visual phenomena is imperative for effective camouflage. The following offers a few cursory observations:

It is generally assumed that the eye resolves two lines or dots which are separated by one minute of arc - i.e. if they are seen at a distance 3440 times their longest linear dimension. The two black lines on white, separated $1/16"$ appear as one line at a distance of about 17 feet. The two black dots, $1"$ in over-all dimension, can not be separated at a distance of 290 feet.

This demonstrates the resolving power of the eye, when there is a large contrast between object and background.

Presence of a gray value, or color value, brings visual acuity into play - the ability of the eye to distinguish fine differences in brightness.

Visual acuity varies widely in different individuals, and is dependent upon adaptation, glare, nature of surroundings, etc. Acuity increases with illumination. It is easy to distinguish even an extremely fine object of the contrast to the background is very sharp (like a fine wire against the sky) but if the background becomes gray, or contrast is diminished, the discrimination becomes increasingly difficult (see black lines against gray, or gray lines against black).

A wire mesh daubed with white, gray, and black spots is placed in front of a gray, a black, and a white cube. Details disappear and pattern is uncertain where the differences in value of foreground and background are small, but white stands out very sharply. This knowledge is valuable in judging the effectiveness of disruptive or concealment patterns.

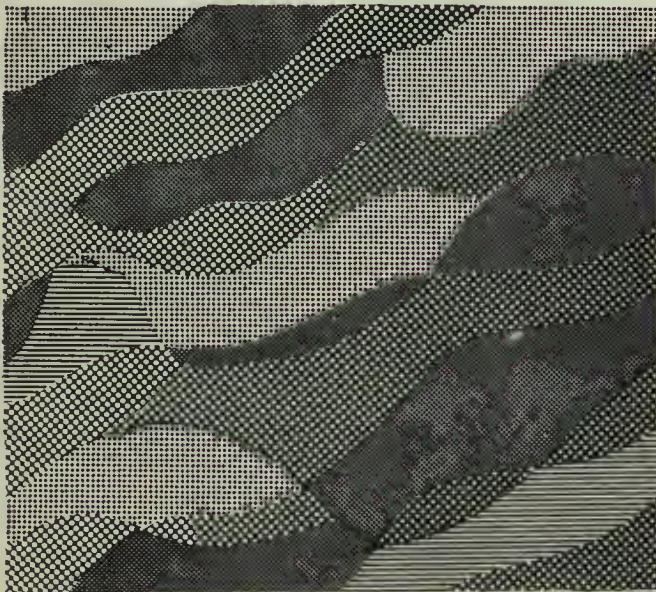
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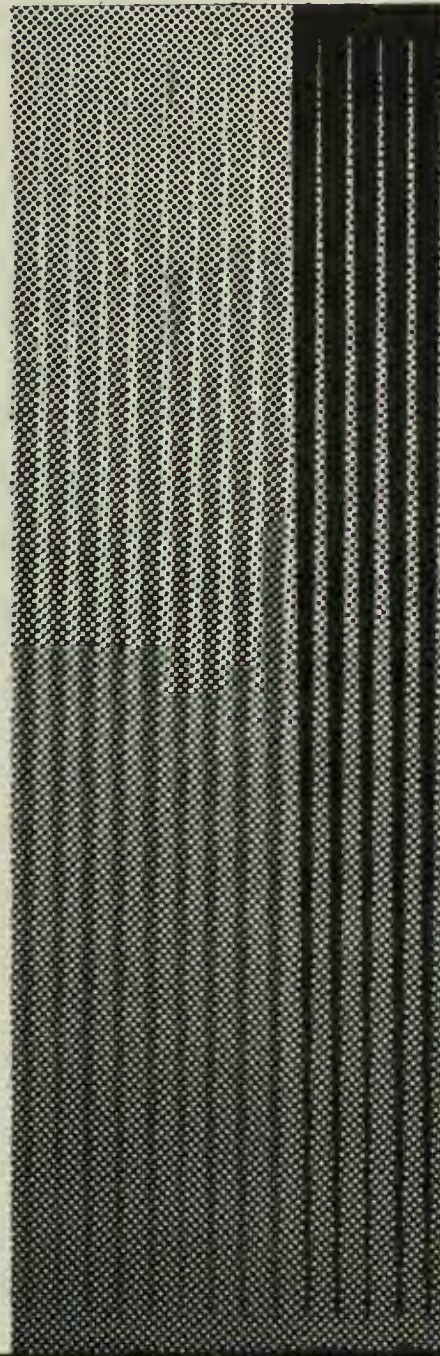
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PERCEPTION OF PATTERN

Examine the two patterns at some distance to test the acuity of the eye with regard to small brightness differences. If brightness of color differences is small the pattern blends to one flat surface. Reduction of intensity through distance and haze increases the effect of a monotone or a monochrome. A big roof painted with a pattern lacking contrast still appears as a big, flat roof.

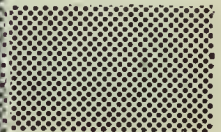


Contrast has to be pronounced and vibrant to produce a natural quality.



This figure illustrates how, with increasing distance, gray values gradually weaken and haze ultimately overcomes color brightness.

10,000 feet



Haze



Gray Value



Color Value

2000 feet



The intensity of color decreases with the increasing distance from the eye. This is a visual phenomenon. The color seen at a distance is weakened in chroma and becomes grayer. Atmosphere and haze generally soften colors. Changes in illumination result in great variations in range and density of color transformation.

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THE MIRACULOUS INFRA-RED EYE



Panchromatic films are so sensitized as to show fairly accurately the same value gradations which we see with the naked eye. Different filters, or differently sensitized films, bring out contrasts which we do not see with our eye.

Infra-red film is sensitive to infra-red rays, invisible to our eye. Chlorophyll in deciduous trees or grass reflects such rays. They affect the film, and photograph white. Fir trees or dark evergreens photograph dark. Sensitivity for various colors is different.

In comparing a landscape photographed with panchromatic (left) and with infra-red film (right), the latter shows greater richness in detail and value separation. Note the branches of trees in the infra-red - the telegraph pole, contrasts in the house, and greater penetration of distance. The successful use of these features, both for concealment and for detection of concealment still needs much experimentation. Paints are offered commercially which claim to produce the same effect as chlorophyll in plants. Other paints photograph lighter too, without being labeled "infra-red". The exclusive adaptation of the camouflage scheme to infra-red photography would overstress its importance. Visual observation and panchromatic sensibility are equally important. It is still the human eye which must spot a target before a bomb is released.

A detailed report on findings of the Pratt Institute Camouflage laboratory on the problem of infra-red will follow at a later date.

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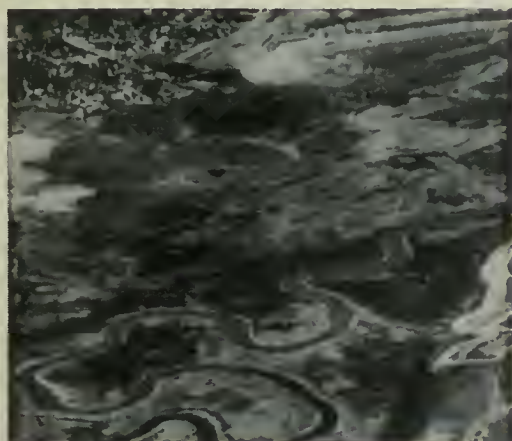
TEXTURE AND PATTERN IN NATURE



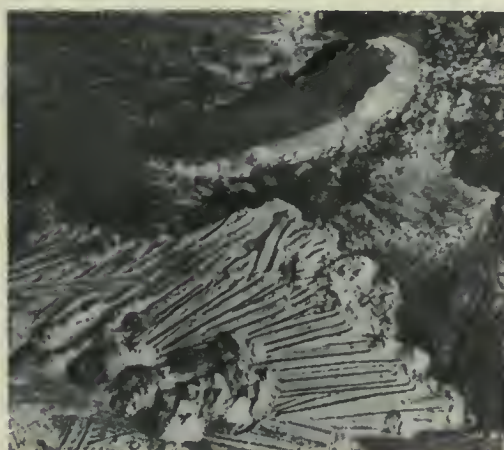
Woodland and meadow.



River valley and swamp on shore.



Marshland and road under construction.



Nature is lavishly rich in variety of pattern and texture, changing with the seasons and perpetually transformed in color, value, and reflections. Study of these forms and experiments to match them artificially are necessary exercises for the camoufleur.

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TEXTURE AND PATTERN IN NATURE - STUDY OF TREES



The structure and shape of a tree are familiar to everybody. Presentation of trees in bird's-eye perspective is the new and exciting problem of the camoufleur. Its realization needs careful study and observation.

The structure as seen from above is very much a structure of light and shadow, a multiform and rugged structure, bristling with fine lights and reflections, but real only through the contrast of shadows.

It is worthwhile to study trees from underneath to learn about the delicate filigree of texture which produces:



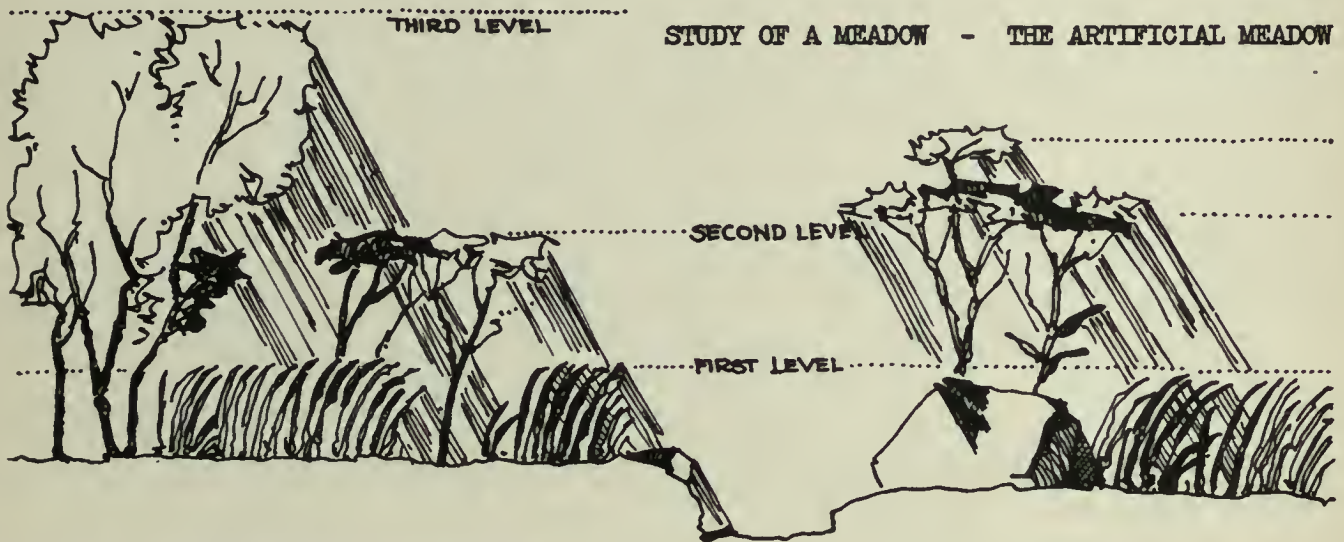
the equally delicate pattern of shadow. Note that the shadow of a tree is not a solid blot.



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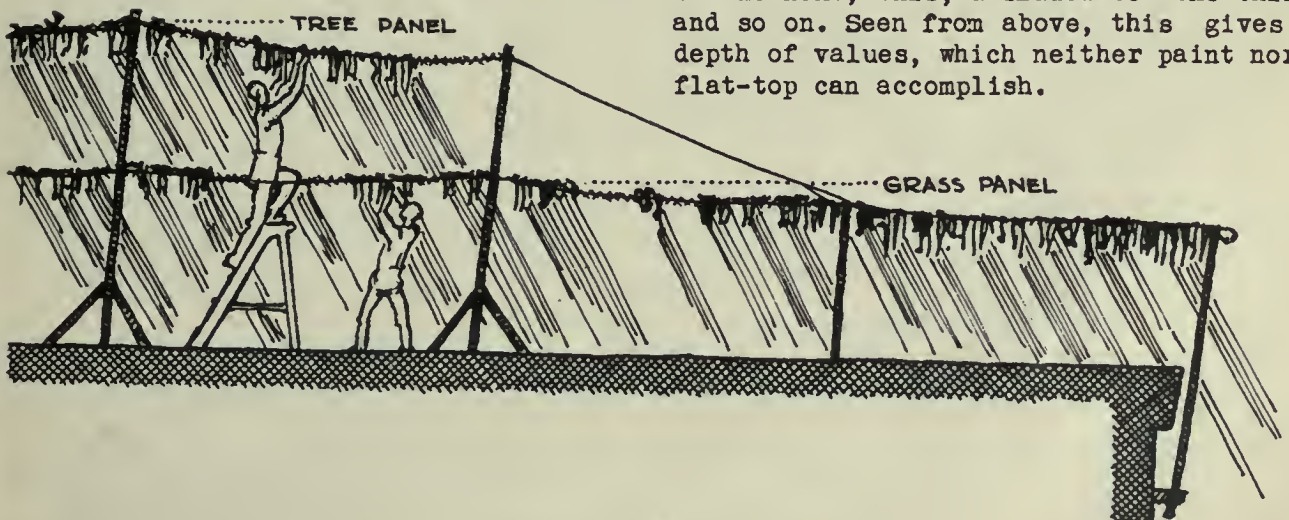
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Grass may be green, brown, yellow, and red. But the coloration is not so important, if seen from a great height. The differences in tone and intensity which we observe in an aerial view are differences in structure rather than in color. The structure of a meadow is rich in light and shadow - a structure in two or three layers. There is primarily the ground, brown or gray, or covered with dry leaves; then grass, the first level - rich in texture and variety. Flowers and herbs form a second level, casting a shadow on the first. Still higher are shrubs and bushes, casting shadows on the grass and on the flowers. The whole "texture" is from four to six feet deep.

The camouflage superstructure is similarly built as a combination of texture and shadow - the highest panel casting a shadow to the next, this, a shadow to the third, and so on. Seen from above, this gives a depth of values, which neither paint nor a flat-top can accomplish.

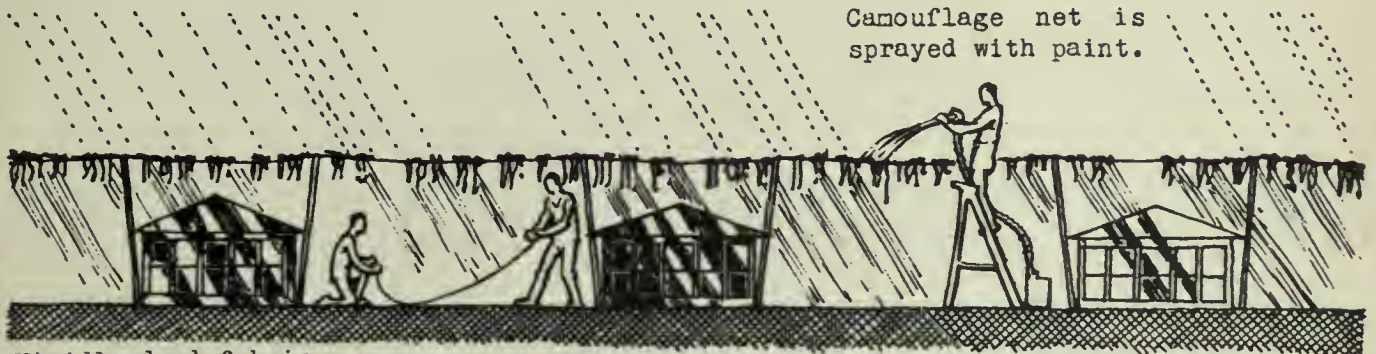


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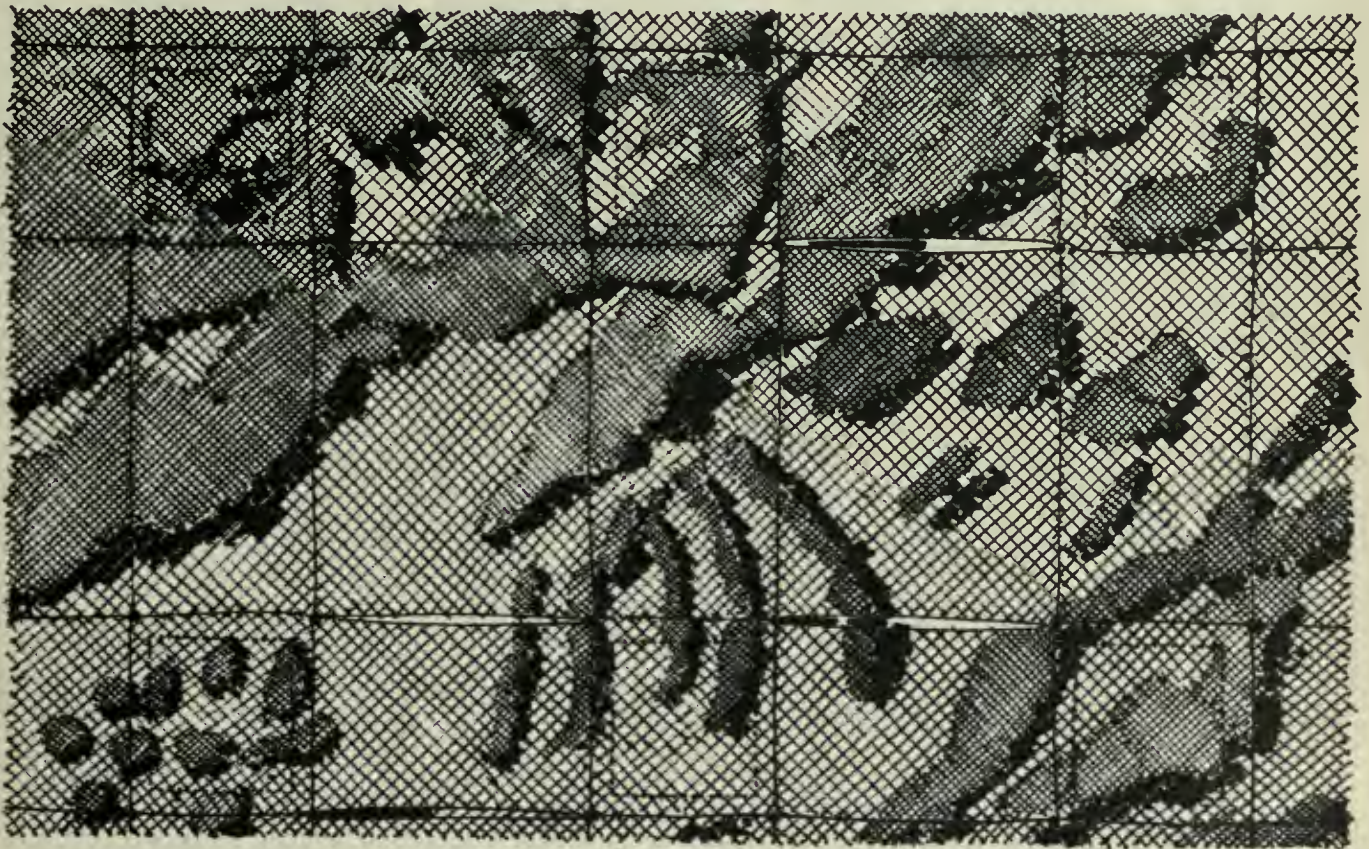
COLORATION AND COLOR TRANSFORMATION



Camouflage net is
sprayed with paint.

Vividly-dyed fabrics
are spread on roof. →

Whatever the original color of the texture material, it will fade in time, get dirty and dusty, and will finally appear gray. Restoring the colors will be necessary. In addition it is imperative to synchronize camouflage colors with those of the adjacent landscape for each season of the year.



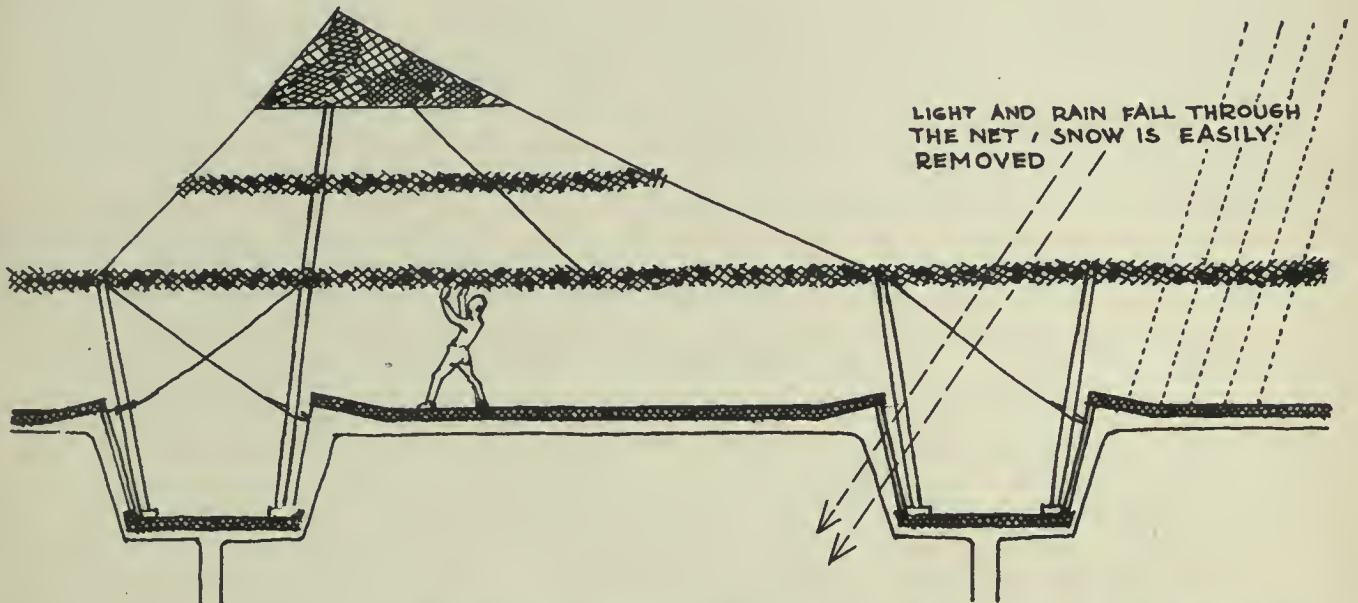
Color transformation can be made in two ways: 1-Spraying the nets (or texture) from above, and 2-Displaying vividly painted boards or fabrics on the roof, below the camouflage construction. This color shines through the openings of the net and gives additional coloration. The pattern should be varied and spotty - not too uniform - with some boldness of detail.

INDUSTRIAL CAMOUFLAGE

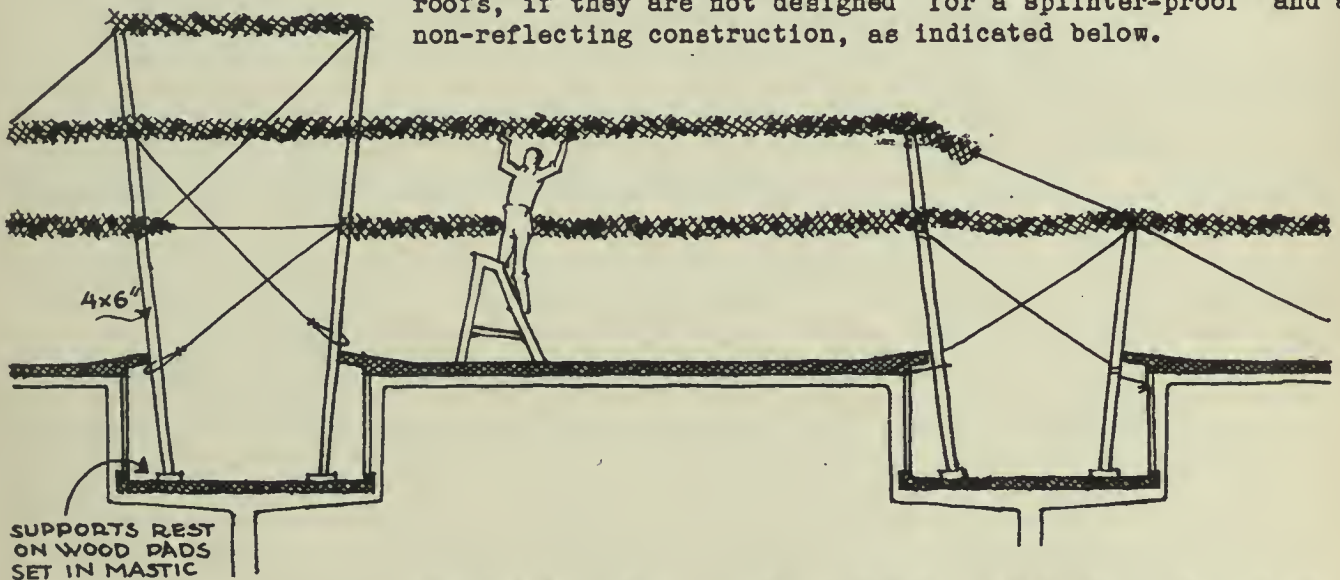
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CAMOUFLAGE OF MONITOR ROOFS



Modern, one-story factories use monitor roofs because monitor roofs provide excellent light of equal intensity. These roofs have the same disadvantages, however, as saw-tooth roofs, if they are not designed for a splinter-proof and a non-reflecting construction, as indicated below.



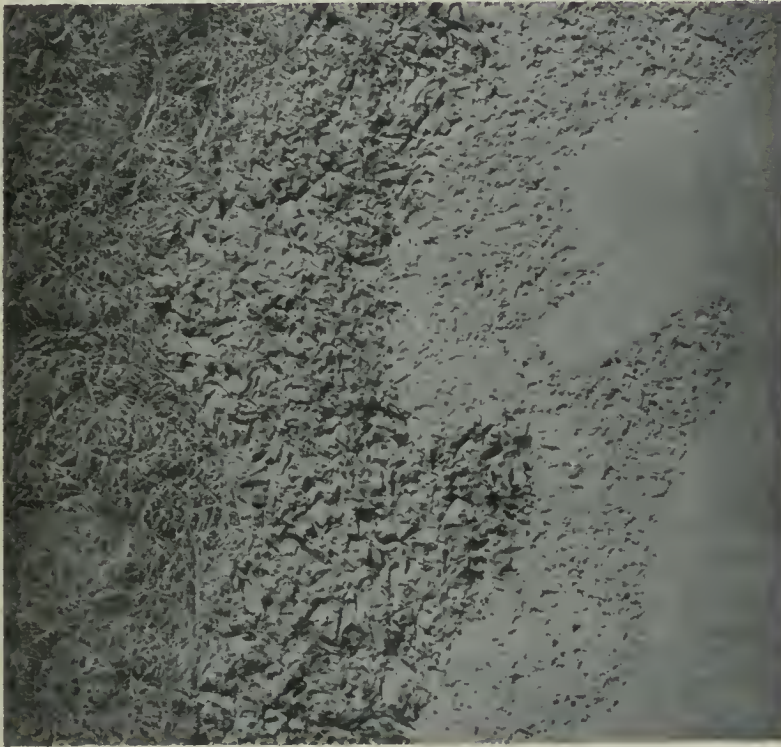
Camouflage of such roofs, by means of nets with texture material, attached on rods and wires six to seven feet (arm's length) above the roof. A second level may be arranged to give more variation to the texture pattern. Vents, chimneys, exhausters, masonry structures on the roof may get additional levels of nets to produce overlapping shadows like the shadows of trees. Nets slope down from the roof to the terrain, covering the shadow of the elevation.

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SHADOW VALUES OF TEXTURE



Panel with different textures, painted all white. Note the different shadow values of the various textures in contrast to the luminosity of a smooth surface. The shadow value depends on the size and density of the shadow-giving particles in relation to the depth of the texture.



1

2

3

4

The same arrangement of textures - smooth, fine-grain, coarse-grain, bushy - but now painted different shades of gray, to effect approximately the same visual value on all textures. The four examples above demonstrate reciprocally the light absorbing quality of the texture.

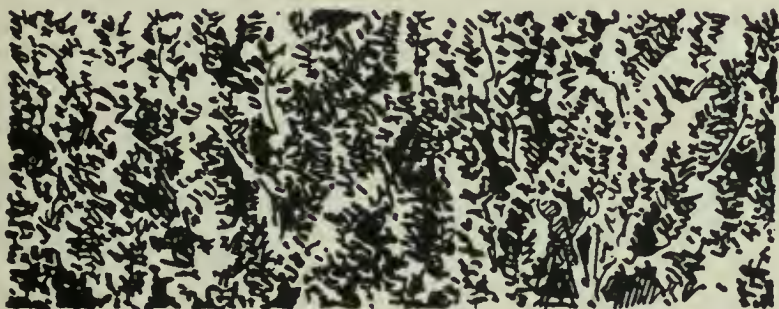


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VARIOUS SUGGESTIONS FOR TEXTURE I



The pattern used must be a pattern of texture (rather than of paint) where variety of shadow-giving structure, proportion, and arrangement of light spots and shadow spots are important in the tonal value.

Woodshavings and excelsior are widely used - light and inexpensive, easily handled and available everywhere. They can be dyed before placement or sprayed afterwards, and readily absorb paint, stains, cement, shellac, and all kinds of emulsions. They can be glued on roofs, twisted in nets, wrapped around vertical structures, and impregnated against fire.

Dwarf shrubs, branches of pine, southern moss, and many kinds of hardy bushes retain their color long after they are dry. They give a very natural-looking texture for all kinds of grassland imitations. The common heather, *calluna vulgaris*, is widely used in Europe for this purpose.

Brushwood, and odds and ends of twigs or branches can be easily sprayed with paint or creosote stains, which dry flat. They are not easily blown off the roof, and can be kept in place by a few wires and a wide-mesh net.

Artificial stones of porous concrete, or of concrete mixed with straw, wood-fibre, sawdust or excelsior, give a rough, coarse, gray, and sponge-like texture, very resistant to weather or fire, easily arranged in rows like furrows of a field and easily stained with all kinds of emulsions.

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VARIOUS SUGGESTIONS FOR TEXTURE II



Slabs of fire-resisting wood fibre boards (Thermax boards) in irregular cuttings produce a fringed outline. These boards are strong enough to make projecting slabs possible without too much support. The fringed edge produces a fringed shadow, which can be matched to other shadows on the adjacent ground.



Strips of wood of different natural colors (or painted in different colors) and of different thickness are placed in irregular cross-hatchings over the object. Self shadow and the cast shadow can be organized to produce an irregular pattern similar to other patterns on the ground.



These are suggestions for makeshift and quick installations which have the advantage of good stability under weather conditions.

.KW.

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THE FRINGED EDGE



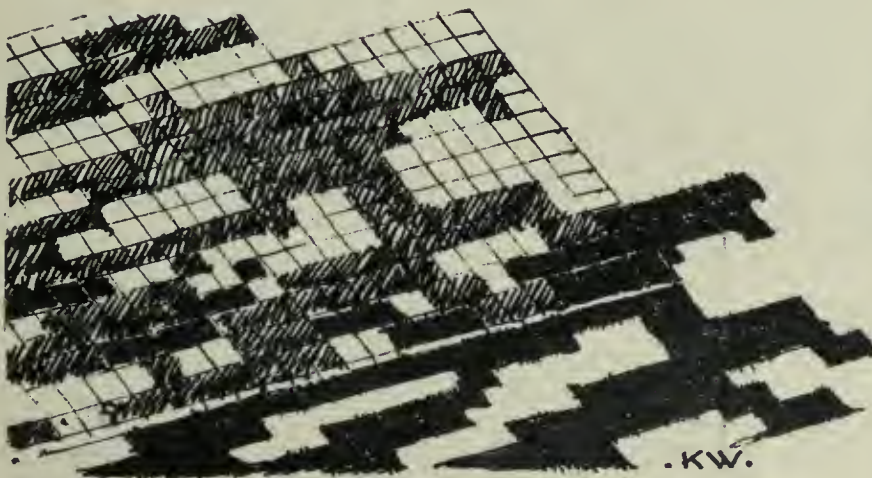
Polygonia c-album

We can learn from nature many interesting tricks of form imitation, disruptive pattern, and color adaptation. But in using these lessons for protective concealment, we have to be aware that the scale of industrial installations, and the expected effect at a great distance makes bolder measures necessary.

Butterflies and moths are perfect examples of protective coloring, and merge with the background by adaptation of shape and behaviour. The zig-zag contour of the wings is aided by dark and light marks to match the pattern of their usual surroundings.



This principle may be used in larger scale to efface a sharp outline. Irregularly spaced boards or slabs cut with irregular outline produce a fringed edge and a fringed shadow.



Steel gratings or wire nets, partly filled in and partly open, produce a marginal pattern of dark and light tones, thus blotting out the straight edge.

.KW.

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TEXTURE AND LIGHT



Landscape painters who tried sincerely to exploit the diversity of forms in nature found even a very small section rich in contrasts of texture, color, and light. Low oblique light brings out fine detail which is lost under vertical illumination. A small grass plot has all the gradations from fullest light to deep shadow.



The deficiency of most camouflage installations is that they look flat and dull. A wrong interpretation of detail obliteration at a great distance results often in neglect of pattern detail. This neglect may be overlooked on small constructions, but too bold a pattern on big installations would be detrimental. Note the different values in a vertical view, which appear comparatively unimportant to ground observation.

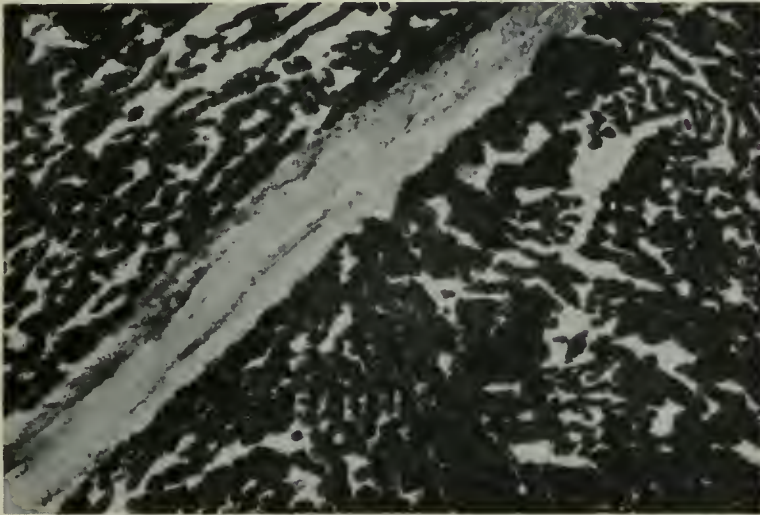


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SHADOW AS PART OF THE PATTERN



These three photographs demonstrate the importance of shadow as part of the pattern for a "realistic" imitation of natural textures.



Figure 1 is a pattern such as is used on expanded nets over flat roofs, representing rough uncultivated grassland, photographed as one flat panel on a white background only. The camouflage net on page 64 would give approximately this effect if only the net is photographed. A road of smooth gray surface crosses the field.



Figure 2 shows exactly the same pattern with the shadow which this pattern casts on an underlying panel. The effect is now a rich pattern of depth and volume, very naturalistic, composed of light spots on the upper panel and light and shadowed spots on the differently-colored lower panel.

Figure 3 introduces a third panel - the "tree panel". Spreading but definite in shape, these tree patterns cast a shadow upon the "grass panel", creating a rich variety of lights, half-shadows, and full shadows, very near to the three-dimensional effect of natural texture.

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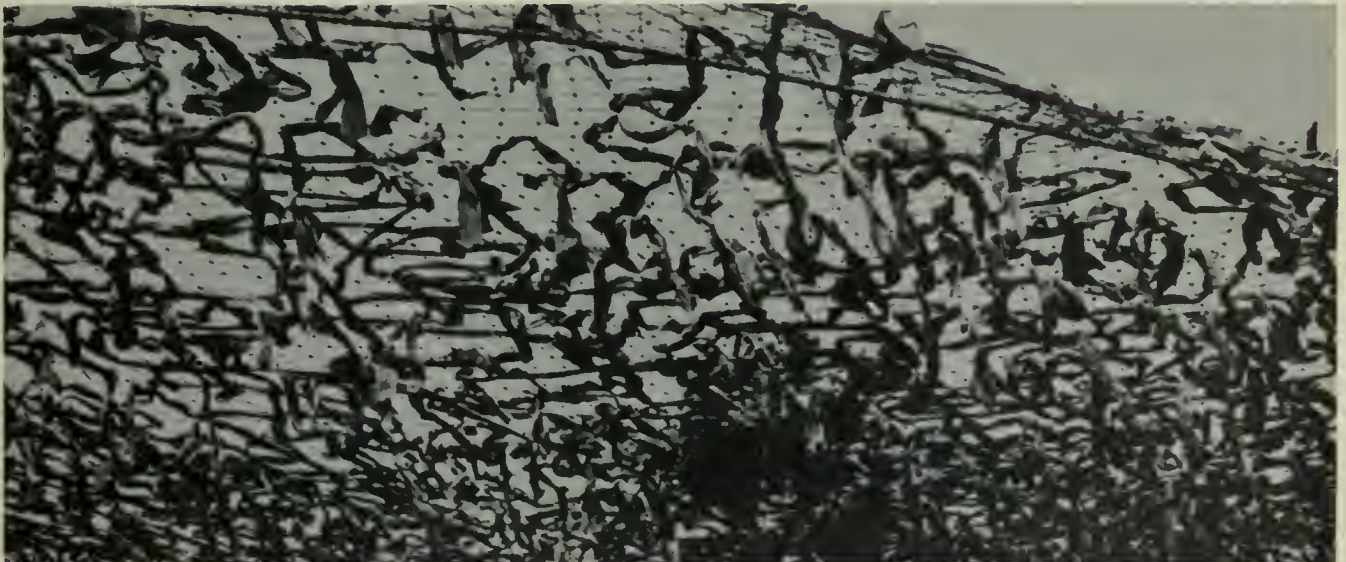
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GARNISHING THE NET



Garnished nets are used for military as well as industrial installations. Experiments with flat-tops provide indispensable experience in color and pattern imitation. Screening of large roofs is a multiple application of the single net, but built for longer duration and greater steadiness. Fishnet, easily folded and portable, is principally used for mobile situations. These nets need much adjustment in changing weather, because they shrink when they get wet and expand as they dry out. Therefore, more stable nets are used for large installations: chickenwire, galvanized wire net, welded reinforcing nets, expanded metal, stucco binder mesh, and even steel grating. The photograph shows fish nets garnished with garlands - strips of cloth or osnaburg woven in and knotted in varying densities, with the ends hanging to increase the effect of depth.



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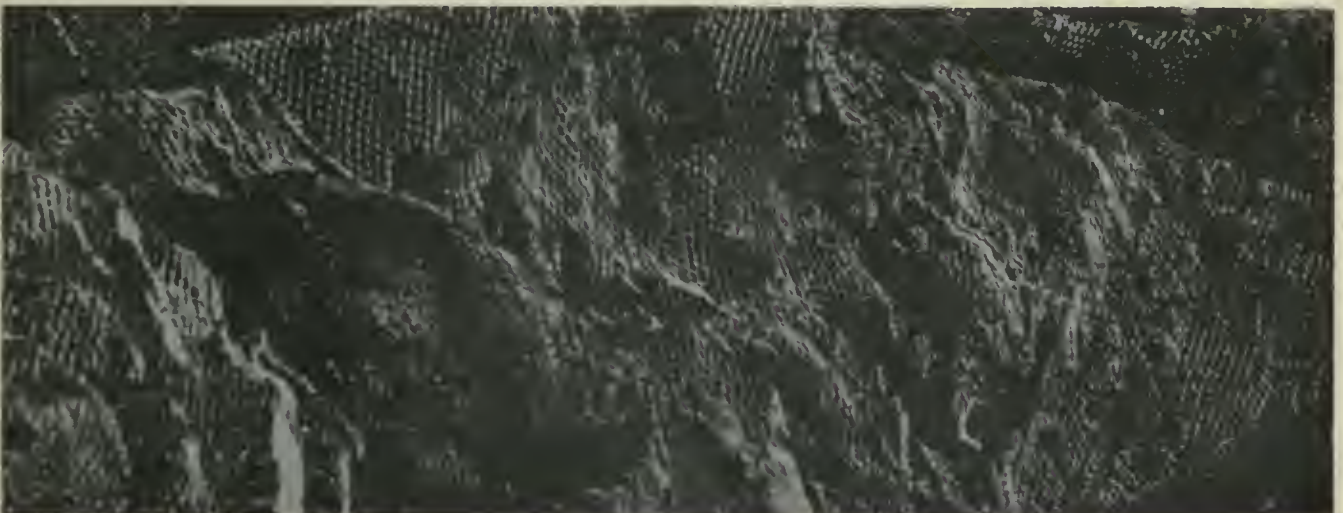


SURFACE MODELING WITH NETS

A net which is filled in thickly appears flat, uniform and solid at some distance - an effect which is not sufficiently broken up by using various colors for the garlands. The net lacks depth. A medium-filled net has the vibrant appearance of natural texture - tiny spots of light and the depth of real shadow. Various intensities of garnishing make it possible to form definite patterns.

The "flat-top", because it is relatively small, is as a rule, flat and parallel to the ground. Larger nets need relief and figuration in order to create a variety of light and shadow. The net can have ridges and hollows, but relief and garnishing must express the same effect.

Below: Example of a slit paper, expanded, loosely arranged. This has valuable qualities to give fine texture, but is practical only for small, temporary installations.



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WIRE, CHICKEN WIRE, AND GARLANDS

1- Chicken wire		Weight		Price
2" 20 gauge standard size	per sq.ft.	22.2 gr.	0.048 lbs.	0.29¢
2- Black annealed Iron wire				
U.S. Std. gauge	ft. per lb.	lbs. per ft.	Price per 100 lbs.	Price per ft.
2	5.44	0.183	\$ 4.50	0.82 ¢
4	7.386	0.135	4.40	0.6
6	10.17	0.096	4.30	0.415
8	14.29	0.070	4.30	0.3
10	20.57	0.049	5.35	0.26
12	33.69	0.030	5.45	0.16
16	95.98	0.0142	7.05	0.073
3- Osnaburg fabric garlands - cost per linear foot				
Width	Material	Painting	Total (F.O.B.)	
3"	.0030	.0022	\$.00520	
2½"	.0025	.00185	.00435	
2"	.0020	.00150	.00350	
4- Osnaburg fabric garlands - 2½" wide				
dry	per ft.	3.65 grs.	0.008 lbs.	
wet	per ft.	13.6 grs.	0.03 lbs.	
frozen, with snow	per ft.	27.2 grs.	0.06 lbs.	



		Thick		Medium		Thin	
		12 ft. per sq.ft.		8 ft. per sq.ft.		4 ft. per sq.ft.	
		grams	lbs.	grams	lbs.	grams	lbs.
Chicken wire 2" 20 gauge, hexagonal, garnished with 2½" osnaburg fabric garlands.							
Dry:	1 sq.yd.	594.0	1.305	462.60	1.017	331.2	0.729
	1 sq.ft.	66.0	0.145	51.40	0.113	36.8	0.081
Wet:	1 sq.yd.	1668.6	3.681	1179.0	2.601	689.4	1.521
	1 sq.ft.	185.4	0.409	131.0	0.289	76.6	0.169
Frozen:	1 sq.yd.	3137.4	6.921	2158.2	4.761	1179.0	2.601
with	1 sq.ft.	348.6	0.769	238.8	0.529	131.0	0.289
snow							

It is therefore safe to assume a load of 1 lb. per sq.ft. garnished chicken-wire.
For variations in this allowance, see page 122.

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ARTIFICIAL TREES I

Artificial trees are built not only to hide installations underneath, but to change the pattern of the landscape all around the factory. Instead of eliminating shadows, they are built to create them.

Artificial trees are built with several nets expanded at different levels. These nets are garnished with texture material, and so filled in that one level casts a definite shadow on the level next below it. The artificial tree should have - like the natural tree - a clear outline and a clear shadow. All wires or ropes are painted a flat, dark color.

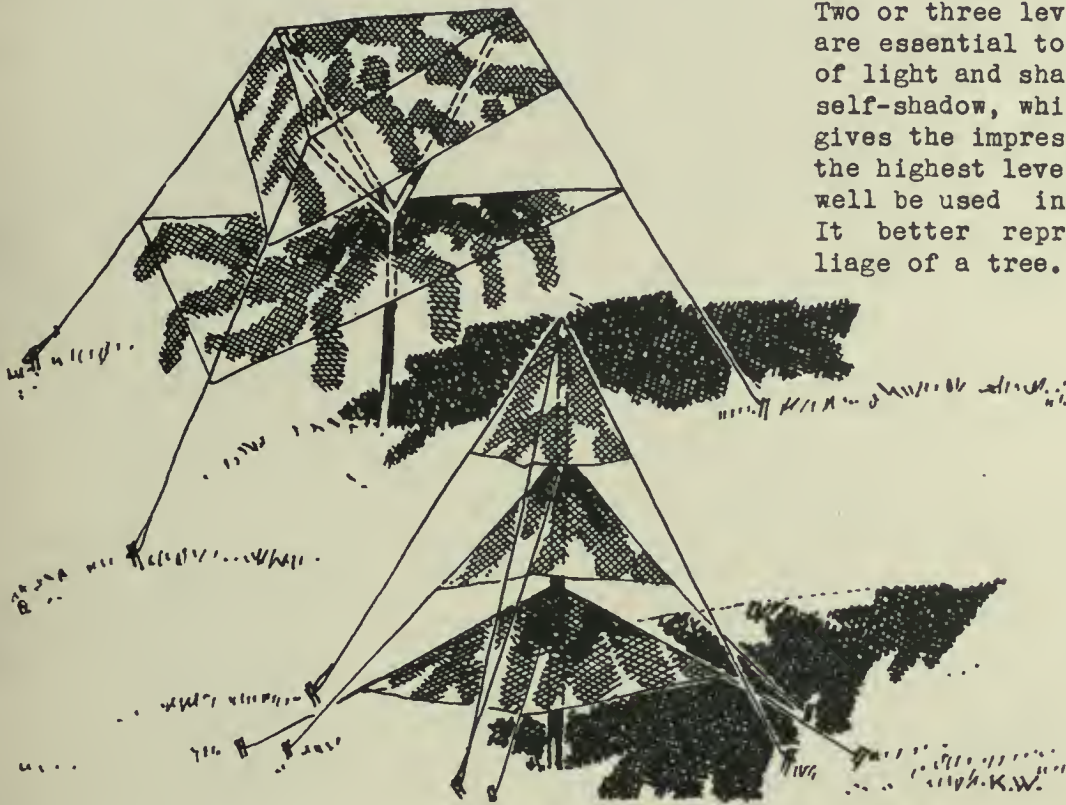
Poles of any kind may be used, provided they are painted dark. Three or four poles are used to produce tall and spreading trees, forming a supporting frame for the highest net, which is garnished like a flat-top. This garnishing should not be too flat or too dense, but should show a loose pattern of spreading branches, casting shadows to the second net and to the ground.

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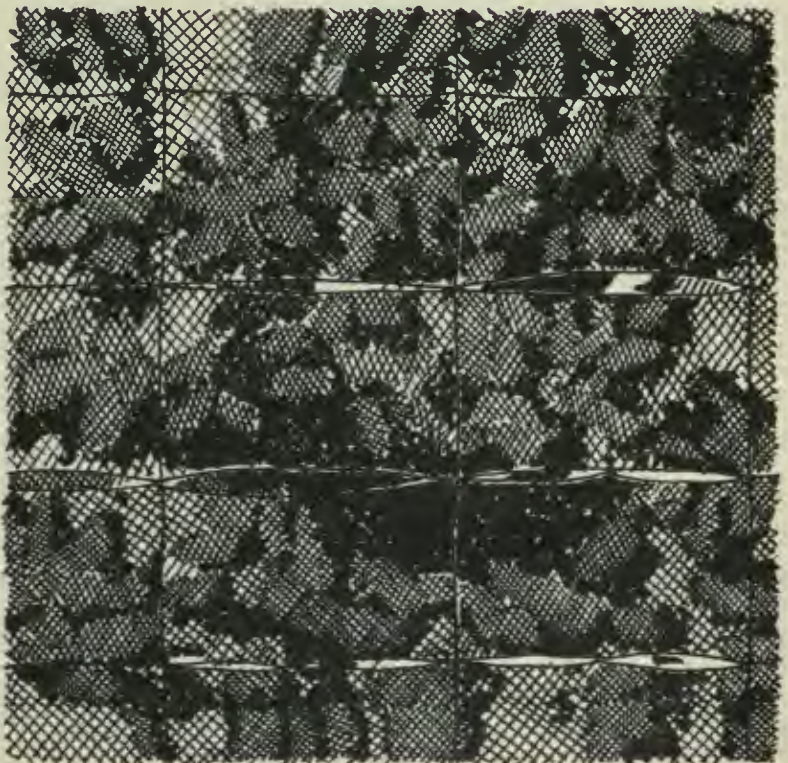
ARTIFICIAL TREES II



Two or three levels of textured nets are essential to produce a structure of light and shadow, cast-shadow and self-shadow, which, seen from above, gives the impression of a tree. At the highest level, a drape-net might well be used instead of a flat-top. It better represents the round foliage of a tree.

Pine trees can be built as a system of several drape-nets. Instead of using wires, the substructure of the artificial tree can be built with a shaft and spokes, opening and closing like an umbrella.

It would be laborious and expensive in time and materials to build a wood of individual trees. It is advisable, therefore, to install flat-top nets in order to cover a wider area. It is essential, however, to have at least two levels of nets. The higher nets, which represent the upper part of the foliage, should not be too much filled, but distinct enough to cast definite shadows. It is important that the pattern of the upper net avoid repetition, and that "shadow parts" in adjoining nets are properly correlated.



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SPECIFICATIONS FOR ARTIFICIAL TREES

A- Tree, 20 ft high, with 2 horizontal nets

Material needed:

- | | |
|---------------------------------------|--------|
| 1- 1 pole, 20 ft high, 4 ft in ground | 24 ft. |
| 2- Wire: 4 x 24 (12 gauge) | 96 ft. |
| 4 x 6 (12 gauge) | 24 ft. |
| 4 x 15 (12 gauge) | 60 ft. |
| cross bracing | 50 ft. |

(approx.) 250 ft.

3- Nets (chicken-wire)

- | | |
|-----------|------------|
| upper net | 36 sq.ft. |
| lower net | 215 sq.ft. |

251 sq.ft.

4- Garlands (upper net medium, lower net thick in center and thin at edge)

250 x 8 2000 ft.

B- Tree, 30 ft high, oblong, with 3 layers

Material needed:

- | | |
|---------------------------------------|---------|
| 1- 1 pole, 30 ft high, 5 ft in ground | 35 ft. |
| 4 props, 10 ft high | 40 ft. |
| 2- Wire: 2 x 40 + 2 x 50 (8 gauge) | 200 ft. |
| upper net: 2 x 10 + 2 x 5 (12 g) | 30 ft. |
| middle net: 2 x 20 + 2 x 12 (12 g) | 55 ft. |
| lower net: 2 x 30 + 2 x 20 (12 g) | 100 ft. |
| cross bracing | 150 ft. |

(approx.) 550 ft.

3- Nets (chicken-wire)

- | | |
|------------|-------------|
| upper net | 50 sq.ft. |
| middle net | 250 sq.ft. |
| lower net | 600 sq. ft. |

900 sq.ft.

4- Garlands (all nets medium)

900 x 8 7200 ft.

C- Tree, 30 ft high with 4 poles - upper and lower net, and drape net

Material needed:

- | | |
|---|---------|
| 1- 4 poles, 35 ft high, 6 inches diameter | 140 ft. |
| 8 props, 12 ft high | 100 ft. |
| 2- Wire: 4 guy wires (8 gauge) | 40 ft. |
| upper net: 2 x 20+2 x 30 (12g) | 100 ft. |
| lower net: 2 x 40+2 x 30 (12g) | 140 ft. |
| cross bracing | 210 ft. |

(approx.) 500 ft.

- | | |
|----------------------------|-------------|
| 3- Nets: upper net 30 x 20 | 600 sq.ft. |
| lower net: 40 x 30 | 1200 sq.ft. |
| sloping nets: 140 x 10 | 1400 sq.ft. |

3200 sq.ft.

4- Garlands (both layers thin)

- | | |
|----------------------|------------|
| 1800 x 4 | 7200 ft. |
| drape net very thin: | 2800 ft. |
| | 10,000 ft. |

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120'

FAST-GROWING AND TALL TREES I

90'

30'



ACER NEGUNDO
Box Elder or
Ash-leaved Maple

ACER SACCHARUM
Hard or
Sugar Maple

AILANTHUS
GLANDULOSA
Tree of Heaven

POPULUS
BALSAMIFERA
Balsam Poplar

POPULUS NIGRA
ITALICA
Lombardy Poplar

120'

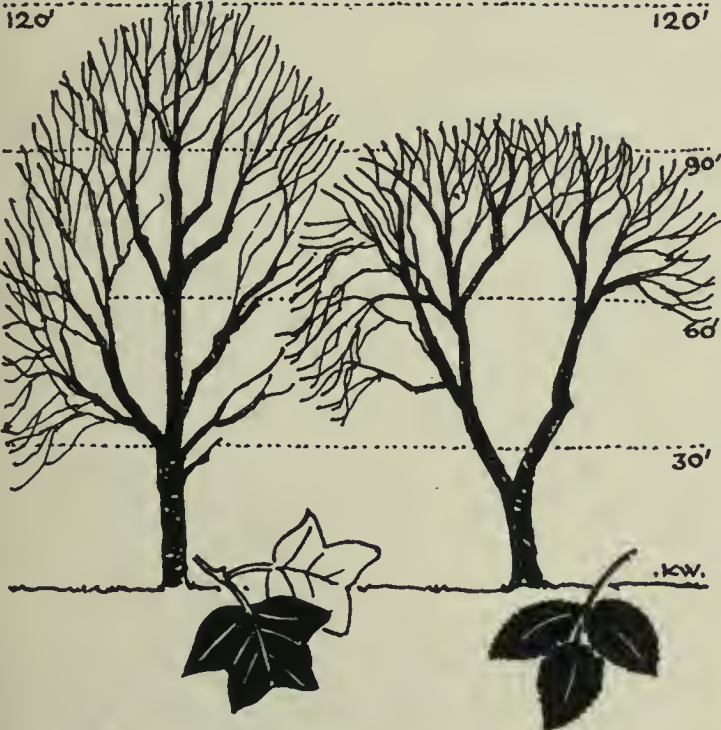
120'

90'

60'

30'

10'



LIRIODENDRON TULIPIFERA
Tulip Tree

ULMUS AMERICANA
White Elm

The choice of plant material plays an important role in the camouflage plan, especially in a planting program for effective camouflage in the future. Rapidity of growth, massive or slender form, branch-spread, duration of foliage, density of branches, early blossoming, or late fall losing of leaves are things which have to be taken into consideration.

Relative Rapidity of Growth of Familiar Trees. From a report by W. F. Fox, Superintendent of State Forests: Three-inch saplings, in favorable situation, will attain in twenty years, the following dimensions:

21" Silver Maple, Box Elder
19" American Elm
18" Tulip Tree, Sycamore
17" Linden Basswood
16" Catalpa, Red Maple, Ailanthus
15" Cucumber Tree
14" Chestnut, Yellow Locust
13" Hard Maple, Horse Chestnut
Honey Locust, Red Oak, Pin Oak
12" White Ash

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120'

FAST-GROWING AND TALL TREES II



POPULUS
DELTOIDEA
Cottonwood

TILIA AMERICANA
Linden or
Basswood

SALIX
BABYLONICA
Weeping Willow

BETULA Papyrifera
White or
Paper Birch

ACER
PLATANOIDES
Norway Maple

120'



SALIX ALBA
White Willow

ACER RUBRUM
Red Maple

New designs for industrial areas should include a landscaping program with trees for shadow absorption and screening against oblique observation. The tree softens the rigidity of the industrial pattern and protects minor installations under spreading foliage. These two sheets of trees can only indicate the importance of the problem, each case needing careful adaptation as to site, soil, and climate.

Fast-growing trees suitable for camouflage purposes are, among others:

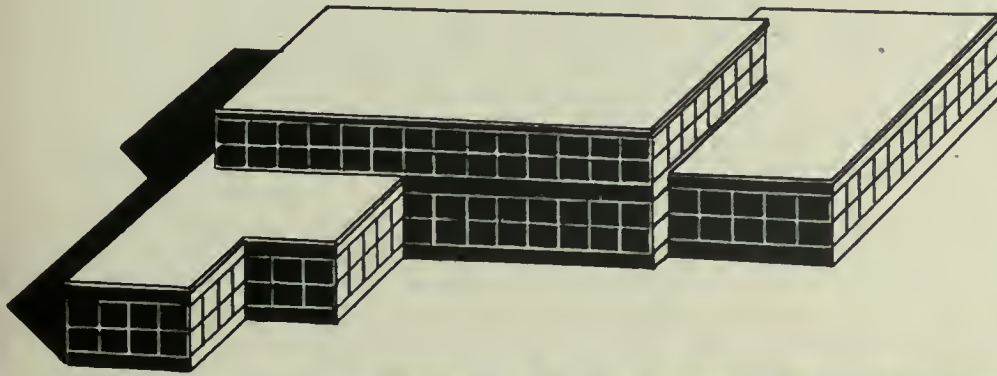
Name	Height	Spread	Shape
Box Elder. . .	50-70.	40.	Spreading
Hard Maple. . .	.120.	50.	.Oval
Silver Maple. . .	.120.	50.	.Oval
Ailanthus.60.	30.	Spreading
Balsam Poplar. .	75-100.	40.	Spreading
Cottonwood. . .	.60-150.	40.	Spreading
White Birch. . .	100.	40.	Spreading
Weeping Willow.	30-40.	30.	.Drooping
Tulip Tree.200.	80.	.Oblong
White Willow. .	.60-80.	50.	Spreading
Lombardy Poplar. .	.90.	15.	Pyramidal
Linden Basswood. .	120.	45. Round
Norway Maple. . .	.100.	60. Round
American Elm. . .	.120.	80.	Vase-shaped

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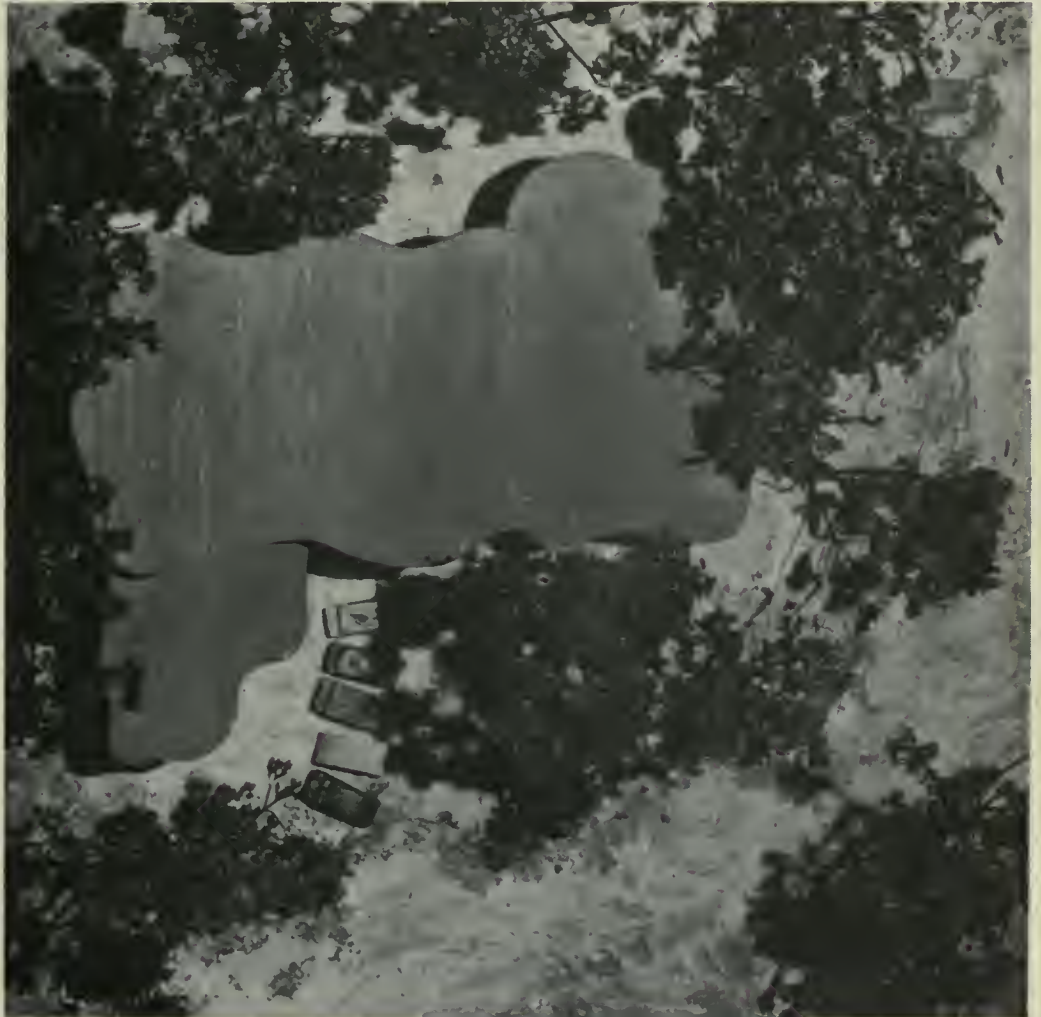
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PART III - DEMONSTRATIONS ON MODELS AND EXAMPLES FOR CAMOUFLAGE PRACTICE



Paint alone would not be sufficient to hide such a building which from each side shows sharp contrasts and marked shadows. An attempt toward camouflaging this building should aim to destroy revealing outlines.

THE CURVED EDGE

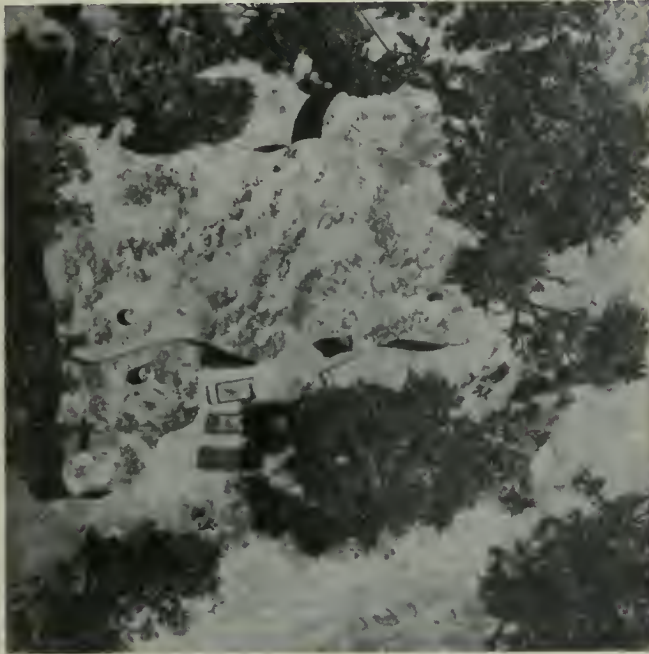


New buildings can use the curved silhouette as an interesting feature in industrial building design. Curving the roof may be especially successful where rolling terrain and trees show similar roundness. Due to the absence of texture there is however, a considerable difference in tone between the flat roof and the ground.

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TEXTURE MATERIAL ON ROOF

The roof is serpentine-shaped and is planted with grass or has an artificial texture of excelsior, wood-shavings, rubbish, etc. Spreading trees surround the buildings and the curved shadows of the buildings blend with the round shadows of the trees.



Shrubs on the roof, quick-growing weeds, or a few higher heaps of artificial texture give an even better confusion of shadows. The round shadows are like shadows of rocks or rugged terrain formations. Cars might still expose the target if not parked under trees or in shadowy places.

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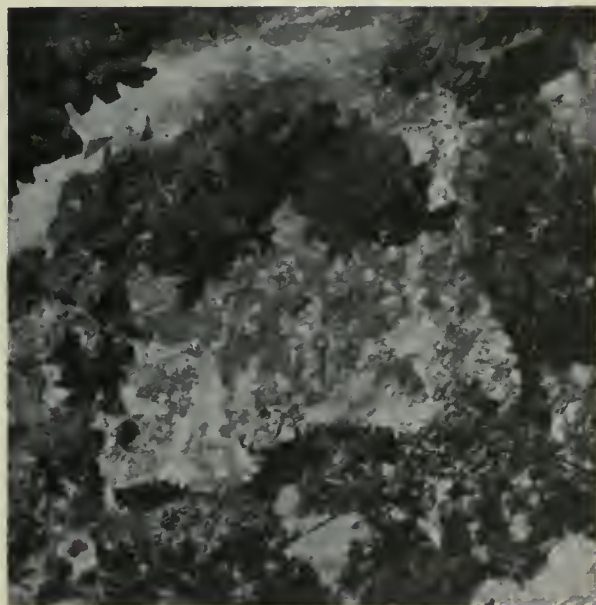
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CURVED ROOF WITH ARTIFICIAL TREES



Projecting roofs cover against not only vertical observation (which is photographic observation) but also effectively against recognition at lower angles. They shadow the elevations, reduce their visibility, and cut dangerous reflections of windows, even if they are not, as designed here, curved or fringed. The projection of roof slabs has to be within reasonable limits of constructive stability, considering the overturning moment of wind pressure, and possible vibrations at anchor points.

The texture of the roof should match closely the texture of the terrain, which sometimes includes reflections and bright spots. The universal use of dark and flat color is therefore not advisable. The roof might appear as a dull spot and therefore attract attention. Paint should not be glossy, but it would be quite as wrong to use only absolutely flat paint.

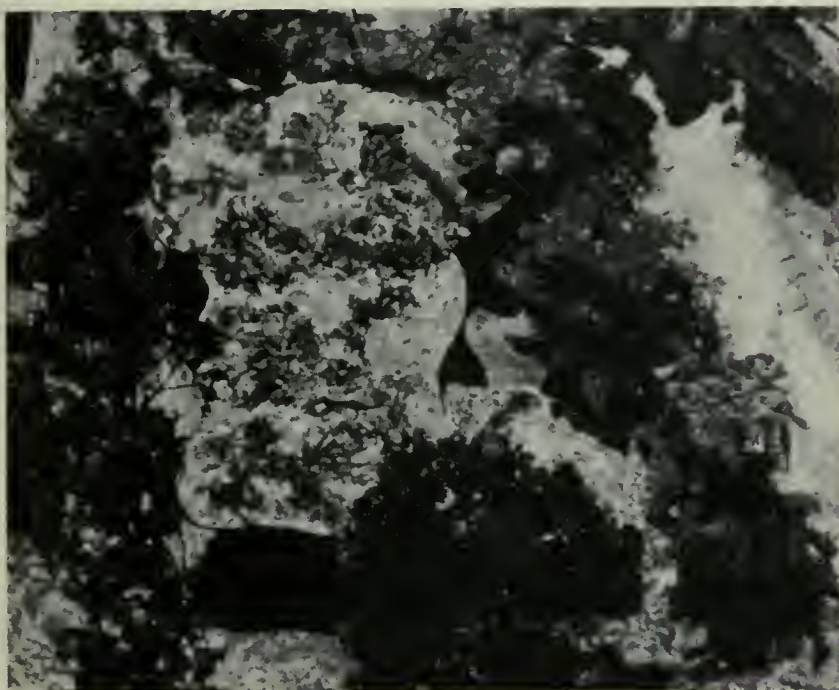


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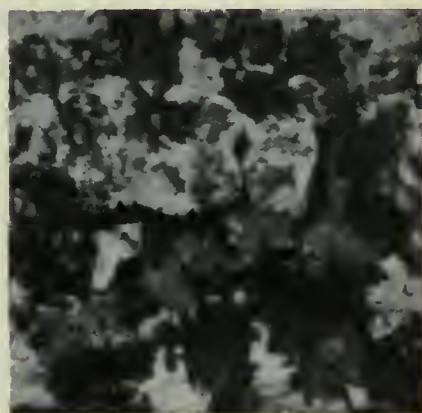
OBLIQUE AND VERTICAL VIEWS FROM HIGH ALTITUDE



Several photographs of the same model with changed light. The intention is not to suppress the shadow entirely but to render the shadow meaningless and to blend it with other natural or artificial shadows of the terrain.



Shadows are most conspicuous in a vertical view. At a distance of several miles and at an angle of maximum 45° this broken shadow would be hardly noticeable.



These two pictures were taken at a height which corresponds to approximately 5000 ft from the actual installation.



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VERTICAL VIEW WITH SHADOW EFFECT OF ARTIFICIAL TREES



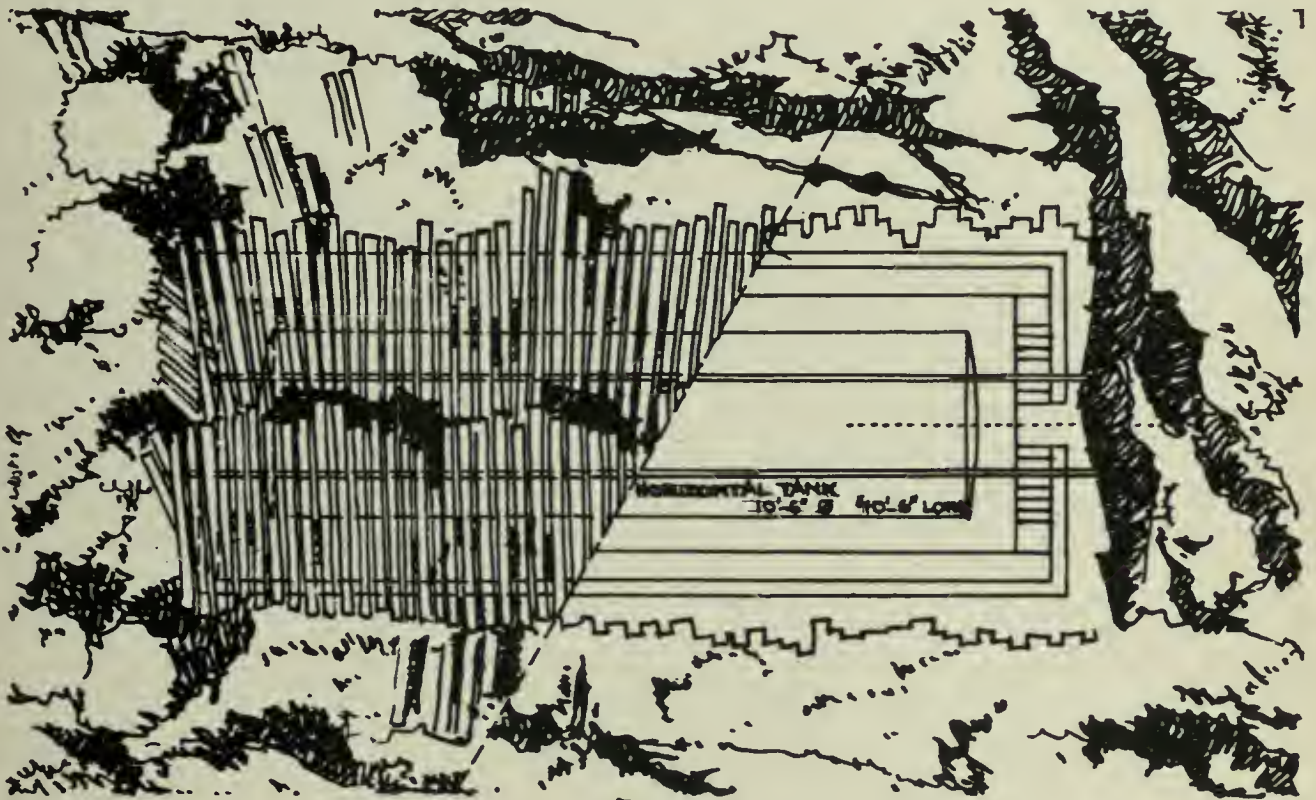
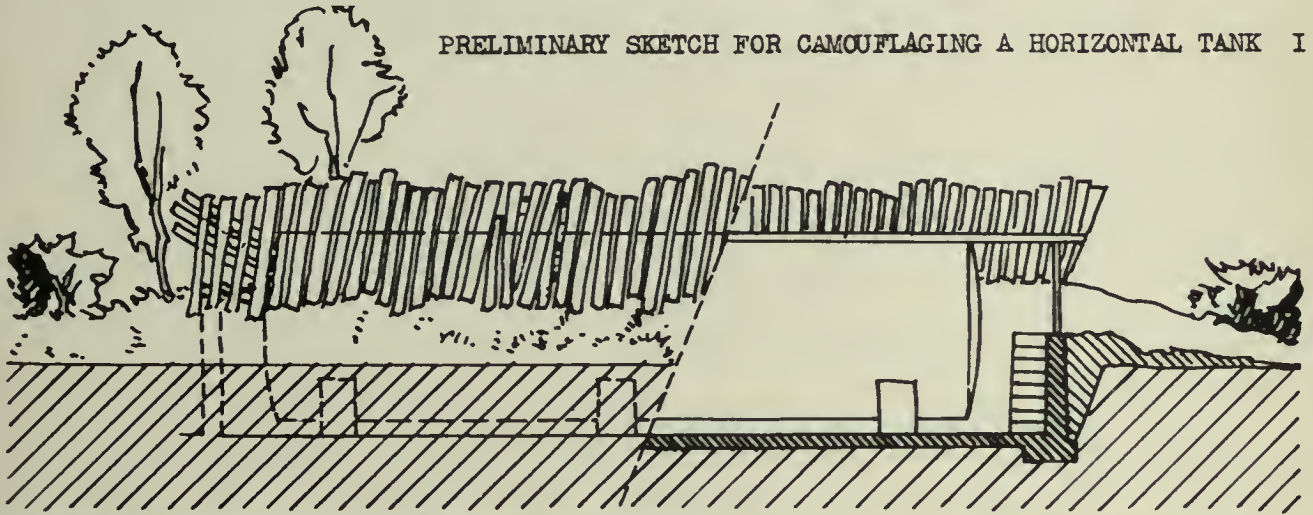
Vertical view of the same building with shadows of artificial trees falling over the roof. The shadow of such trees looks solid on scale models, but it can be feathered out on actual installations. Dark wires of these trees cannot be noticed against a dark terrain.

INDUSTRIAL CAMOUFLAGE

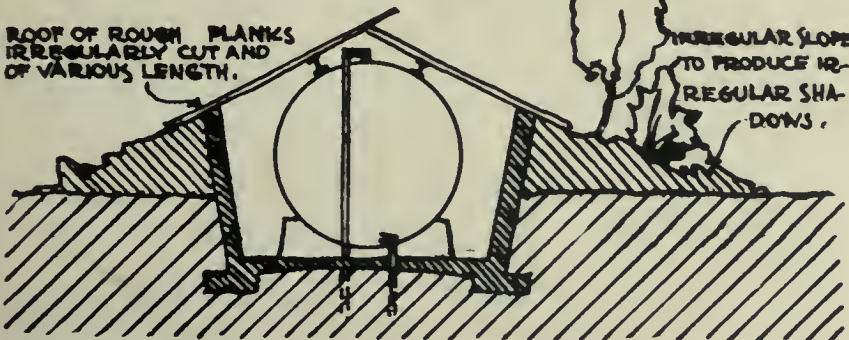
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PRELIMINARY SKETCH FOR CAMOUFLAGING A HORIZONTAL TANK 1



ROOF OF ROUGH PLANKS
IRREGULARLY CUT AND
OF VARIOUS LENGTH.



IRREGULAR SLOPE
TO PRODUCE IR-
REGULAR SHA-
DOWS.

The tank is built in an em-banked pit, which is nor-mally without cover. The cover of this pit consists of random cuttings of small boards or saplings. Care must always be taken to form a pattern of light and shadow somewhat similar to that of the adjacent terrain.

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SHADOW DISTORTION WITH ROOF OF IRREGULAR BOARDS



Camouflage of a horizontal tank with a roof of irregular boards which are so placed as to avoid a straight ridge or straight shadows. Shadows merge with shadows of trees. Several tanks should not be lined up in a straight row.

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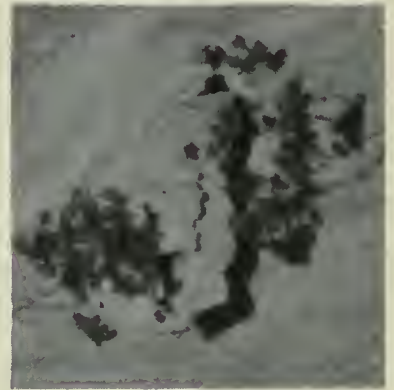
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SHADOW DISTORTION TO BLEND WITH OTHER SHADOWS ON
THE GROUND

Vertical view of model on page 86

The design takes into consideration that such constructions should be erected at short notice and with available boards as a carpenter construction. Painted dark, the jagged shape might stand for a group of trees.

The small picture (right) shows the model taken from a great distance.

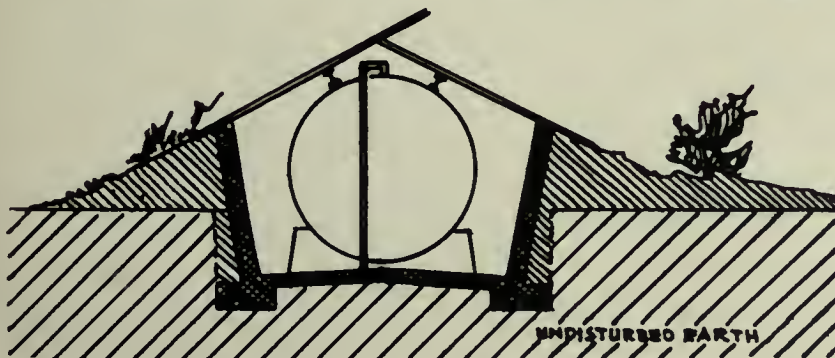
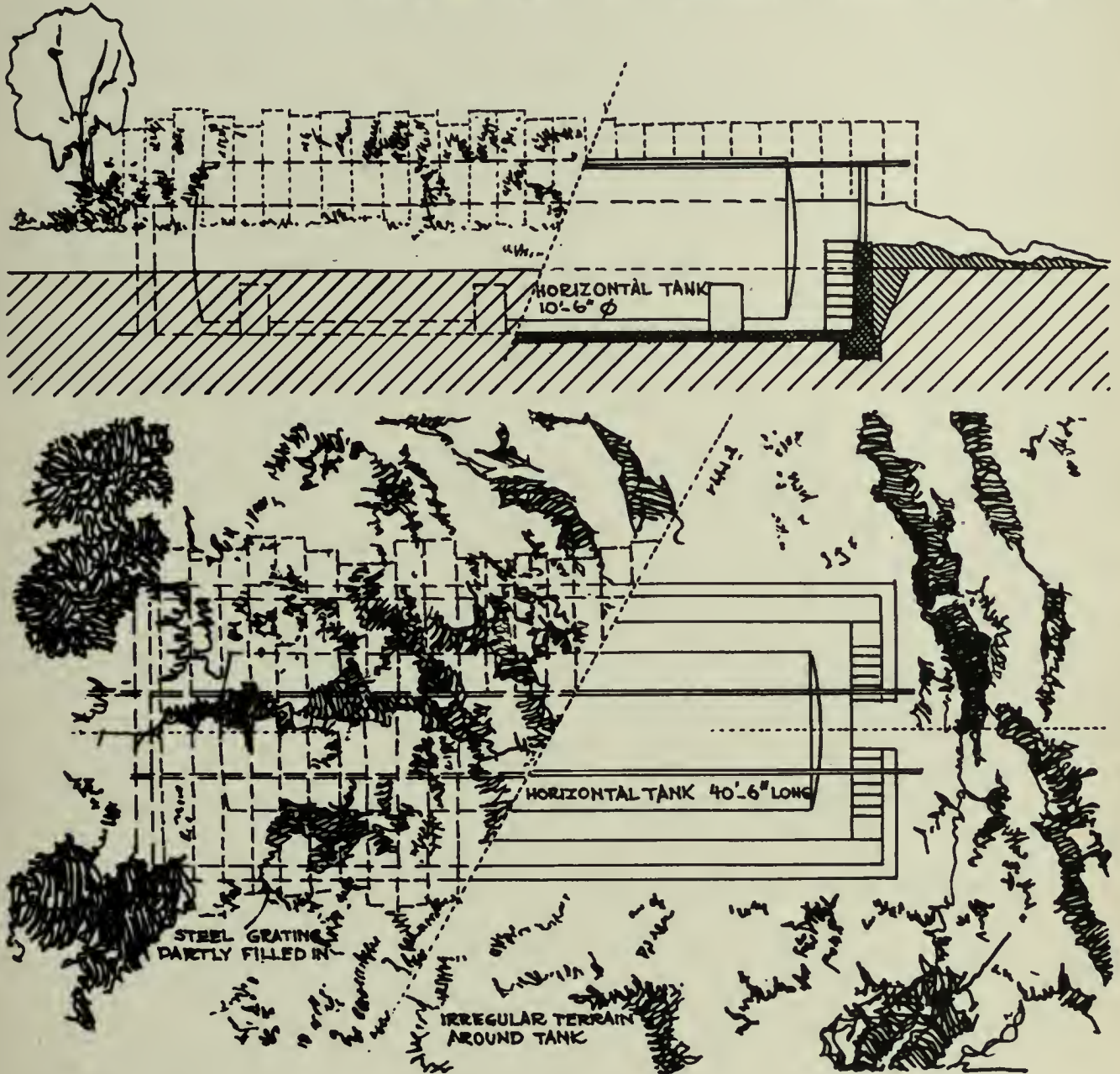


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PRELIMINARY SKETCH FOR CAMOUFLAGE OF A HORIZONTAL TANK II



Steel grating in easily-transportable sizes, partly open and partly filled in with plaster or bituminous emulsions, forming a diagonal pattern and a crooked ridge. Quick-growing weeds can be used to produce natural texture.

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Steel grating or expanded metal in standard sizes can be used to cover horizontal tanks, tank pits, pipelines, drains, railways, exits, etc., as a sturdy and passable construction, easily applied and removed. Solid boards are, in many cases, too smooth and give a too definite shadow. An effective texture of light and shadow is created by daubing the gratings partly with cement, plaster, or mastic compound.

PROTECTIVE
HOODS FOR
HORIZONTAL
TANKS



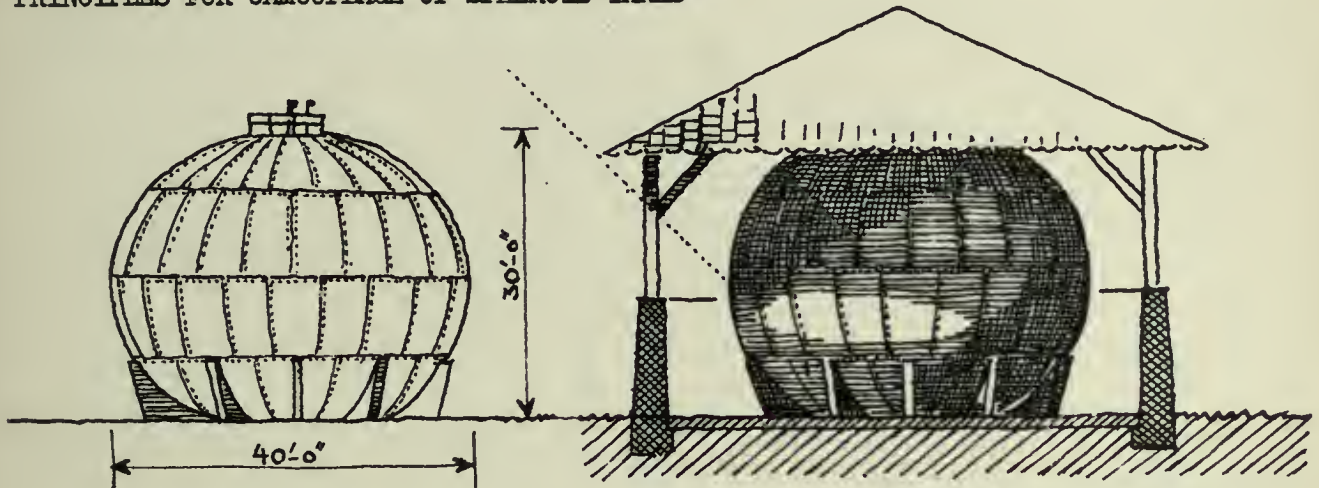
Low walls
bear the gra-
tings, and at
the same time
separate the
tanks.

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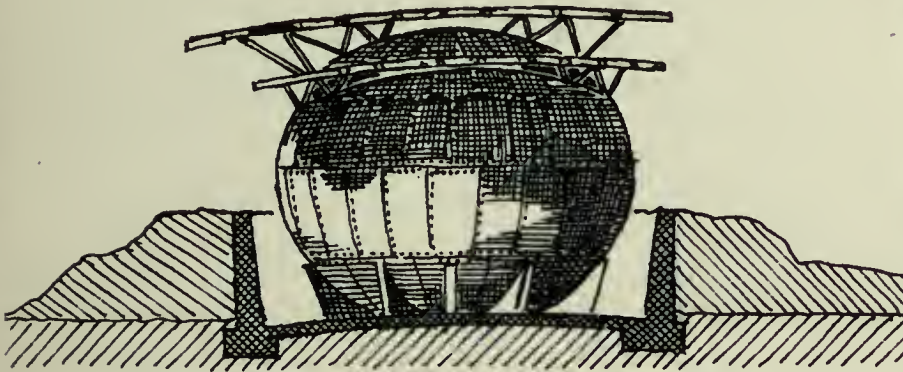
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PRINCIPLES FOR CAMOUFLAGE OF SPHEROID TANKS



These tanks are mostly of bright metal and, by their spherical form, reflect the light strongly.



A practical and permanent method of concealing such tanks would be to build a square roof over them, imitating a house, with a protecting wall to avoid inundation and spreading fire. This is advisable however, only in a surrounding of similar structures.

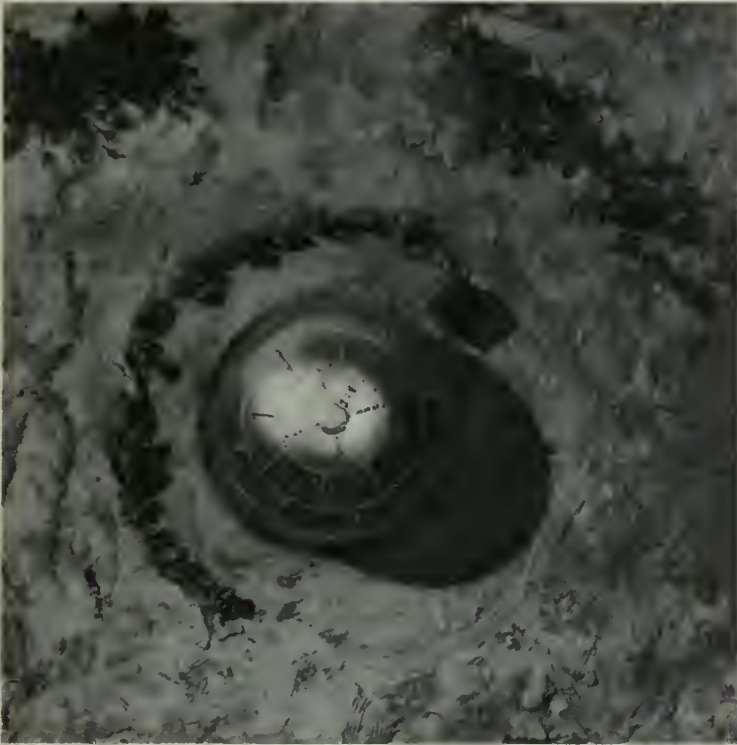


If embankments and varied terrain can be created, a light "roof" of irregular shape is advisable. This roof can be constructed of light trusses, and lightweight boards, in order to produce irregular shadowlines, which will blend with the shadows of the terrain.

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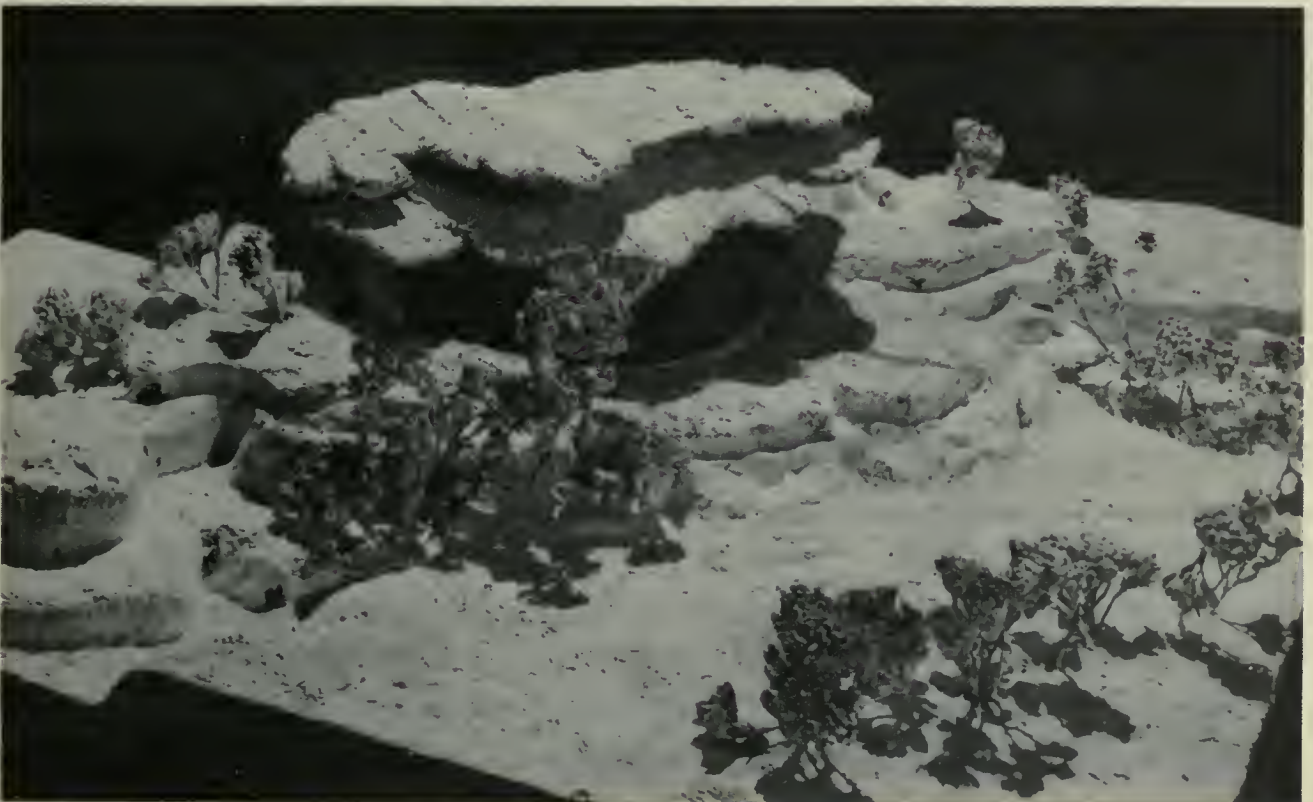
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TERRAIN IMITATION OVER SPHEROID
TANKS

The principal idea for the suggested camouflage construction - in the form of a two-tiered hood on light trusses - is to replace the conspicuously round shadow by several long shadow - lines which blend with other shadows on the ground. This intention is facilitated if the surrounding terrain is of rugged, irregular structure. An embankment is raised around the tank to cut the light, but it is not built as a concentric mound.

The photograph below shows the model on the next page before it was painted.



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SUPERSTRUCTURE IN TWO TIERS OVER SPHEROID TANK



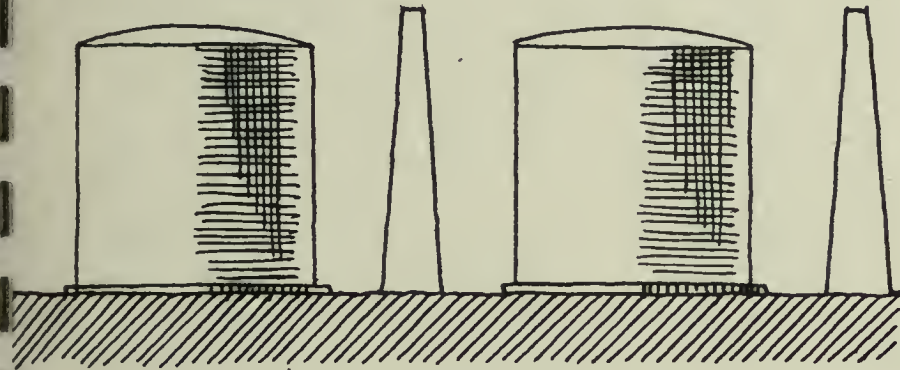
Vertical view of the superstructure covering the spheroid tank. This hood, built in two tiers, to diminish the height, is irregularly shaped to conform with local terrain, thus casting similar shadows. It is advisable to place such tanks in a natural or cement pit and to reduce white pavements to a minimum. Natural vegetation should be allowed to grow as close as possible to the tank to facilitate blending of shadows.

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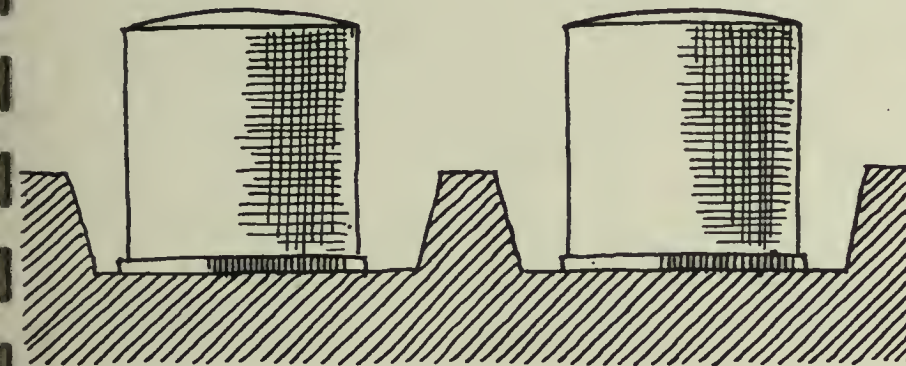
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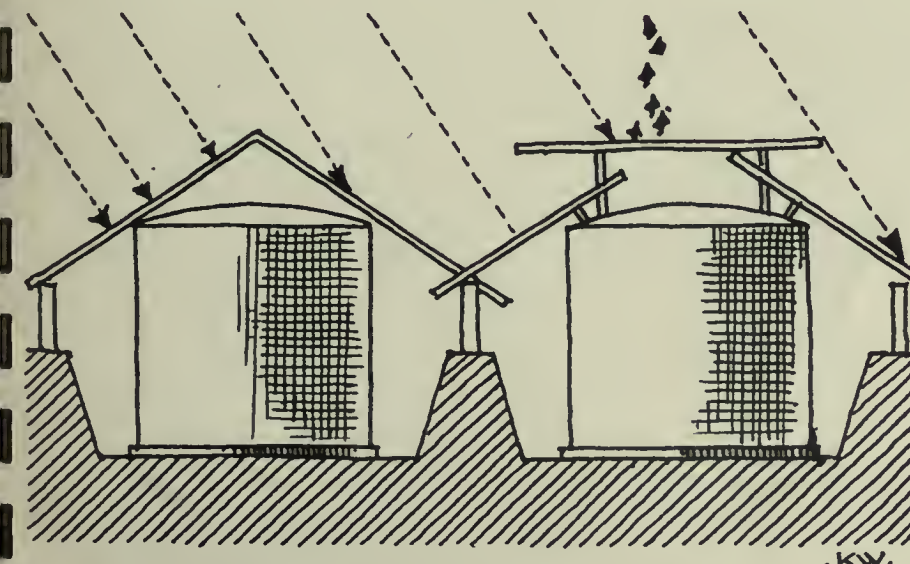
PRINCIPLES OF AIR-PROTECTIVE DESIGN OF STORAGE TANKS Partitions and Hoods



The simplest method of preventing the spread of fire from one row of tanks to another and to localize to one row the blast caused by a bomb striking in the vicinity of one tank, is to use concrete partition walls. This is especially advisable in existing rows of tanks.



Embankments prevent inundation and spreading of fire. The contents of the tank can be conserved if the tank or the pipelines are damaged. These embankments need not necessarily be round. They might better be square or irregular in shape to distort straight shadows.



Provisions should be made to place hoods in wartime over tanks as camouflage to eliminate or distort shadows and to protect the tanks against splinters and light bullets.

These hoods make use of the shadow reduction of a low grade or they would be so constructed that confusing shadows are produced.

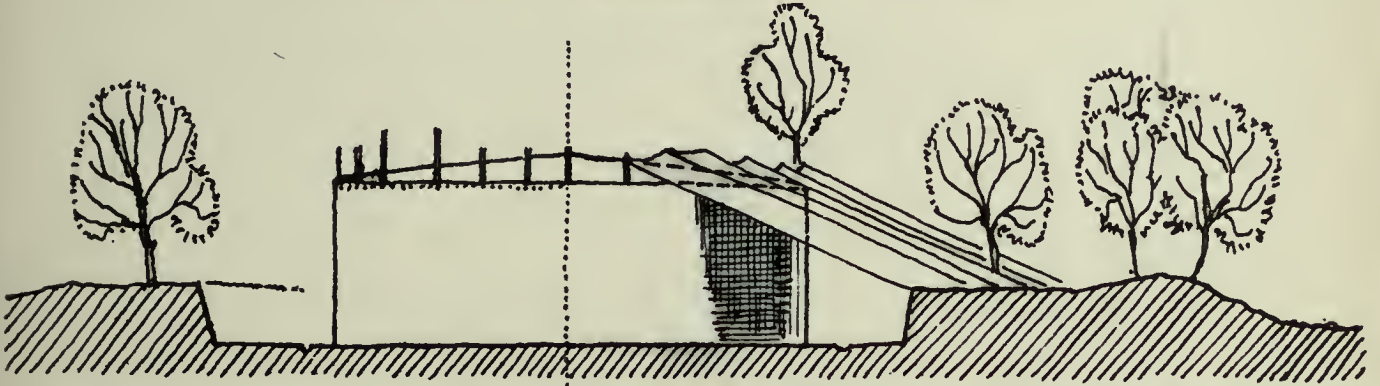
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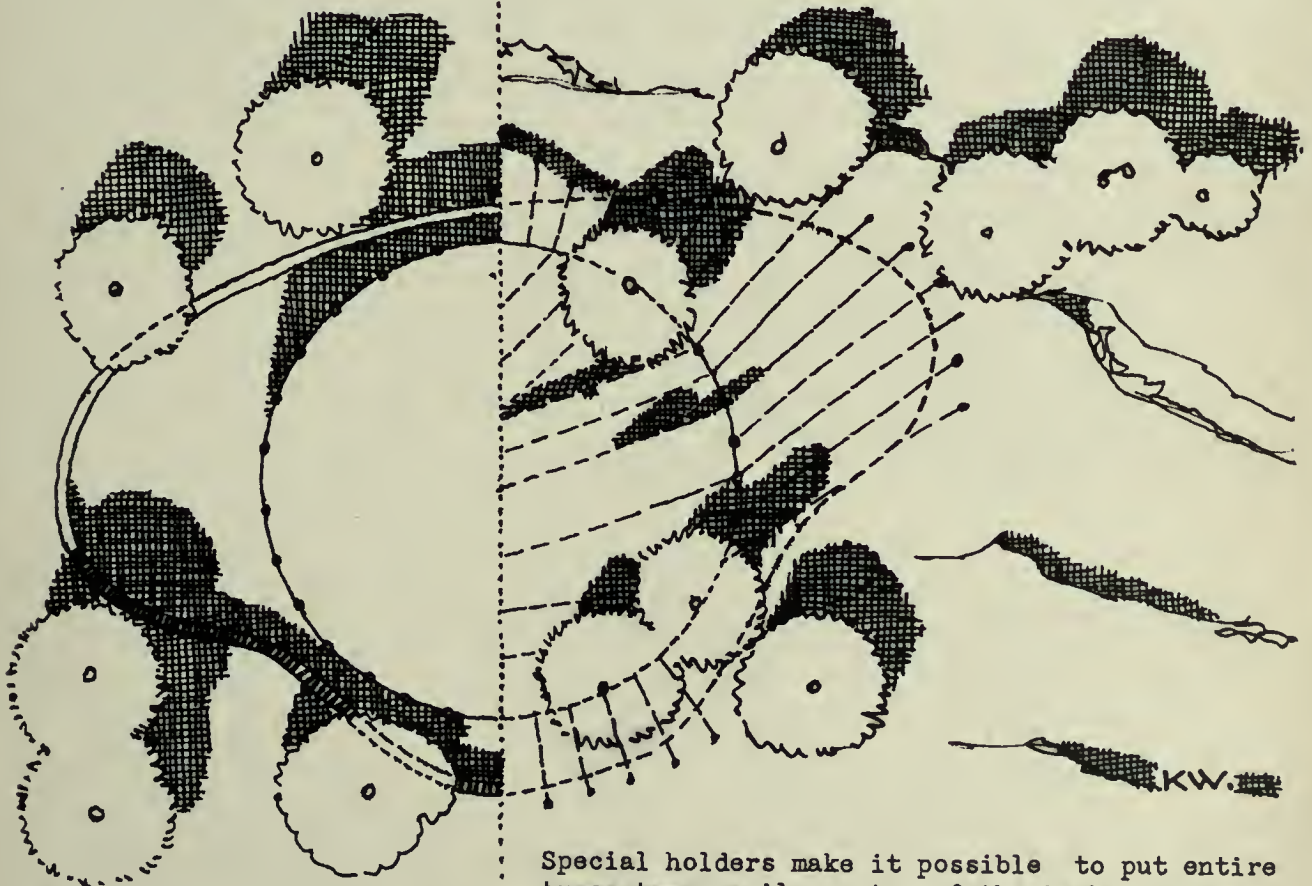
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PRINCIPLES OF AIR-PROTECTIVE DESIGN OF STORAGE TANKS Embankments



Embankments are useful to conserve the contents of the tank if the tank or the pipe lines are damaged.

These embankments are of irregular shape to avoid the prominence of concentric circles. An irregular formation of lines and slopes is produced by means of nets which are spanned from the top of the tank to the edge of embankment. These nets should not be regularly round like circus tents.



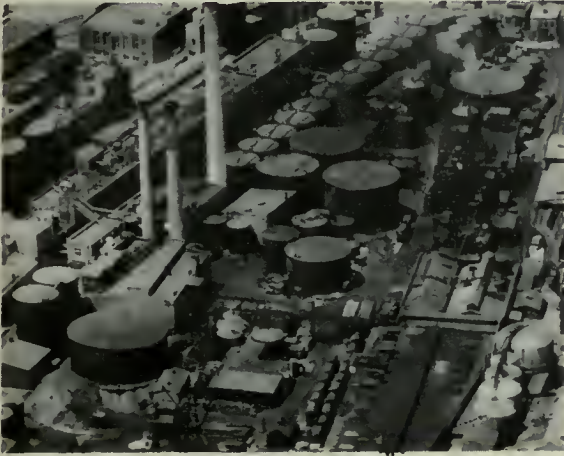
Special holders make it possible to put entire trees temporarily on top of the tank, thus making concealment in wooded areas still more complete.

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EVOLUTION OF DESIGN FOR PROTECTION OF STORAGE TANKS

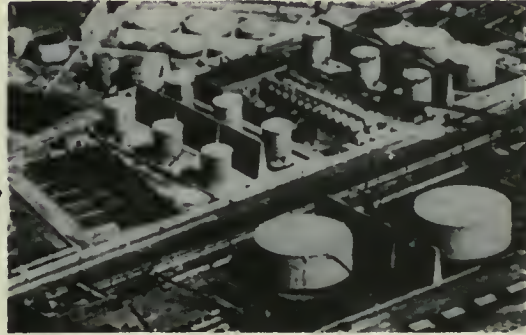


Easy to find
Easy to aim at

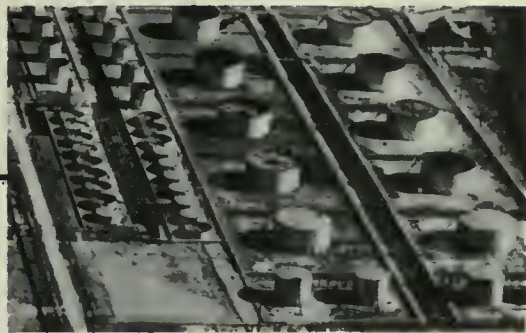


Profitable to bomb - with the following disastrous effects:

- 1- One explosion destroys the whole group
- 2- Fire expands at a highly accelerated rate
- 3- Fire fighting is difficult if not almost hopeless
- 4- Severe danger to adjacent buildings
- 5- No localization of damage
- 6- Loss of contents
- 7- Inundation
- 8- Complete destruction



Separation



Embankments



Dispersion



Landscaping

Difficult to find
Difficult to aim at

Unprofitable to bomb - with the following advantages:

- 1- Fire is confined and controlled
- 2- Fire fighting is facilitated
- 3- Contents are preserved
- 4- Camouflage is inexpensive
- 5- Damage is localized
- 6- Loss is only partial
- 7- Minimum destruction



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SUGGESTIONS FOR INDUSTRIAL CAMOUFLAGE DESIGN PROTECTION OF TANKS

Protection of Tanks should be developed in two Directions:

I- Reduction of Visibility to evade Bombardment

A- Dark paint instead of aluminum and white paint

Dark paint, however, causes greater evaporation losses. According to a Report of Investigations on Reduction of Evaporation Losses from the U. S. Bureau of Mines, these losses are 150 to 180% higher if dark paint is used as against white paint or aluminum foil.

B- Dark infra-red paint which photographs light, like foliage, and is heat-reflecting.

C- Confusion:

Distortion of the shape and shadow of the tank, especially to eliminate the essential roundness.

Listed in the order of their protective value:

- 1- With disruptive painting (dazzle-painting)
- 2- With texture pattern
- 3- With an addition of slabs on roof, projecting over the edge.
- 4- With false or real trees.

D- Concealment:

5- With super-structures on scaffolding, to cover the round contour.

6- With nets over the roof.

7- With nets from the top of the roof to the ground.

E- Deception:

Building a roof, a house, or a jacket around the tank, reducing at the same time, evaporation losses.

II- Measures against Inundation and Spreading Fire after a Hit

(A thru E are arrangements to meet normal danger of fire in peacetime, without considering aerial observation.)

A- Partitions between rows of tanks mostly built as tapered concrete walls, about the same height as the tanks.

B- Greater distances from tank to tank and low walls all around to prevent inundation.

C- Still greater distance between tanks and surrounding embankment providing, at the same time, for a protecting roof.

D- Tanks placed separately in a circular pit, with the same effect as an embankment. (The circular pit of white concrete is, however, very conspicuous to the aerial observer.)

E- Embankment equipped with an automatic sprinkler.

(F thru I are suggestions for danger areas from the standpoint of aerial attack)

F- Embankment of an irregular contour to blend with the natural terrain.

G- Tanks distributed over a larger area, to avoid lining them up in rows.

H- Tanks built on rolling terrain, and trees planted to cause confusing shadows.

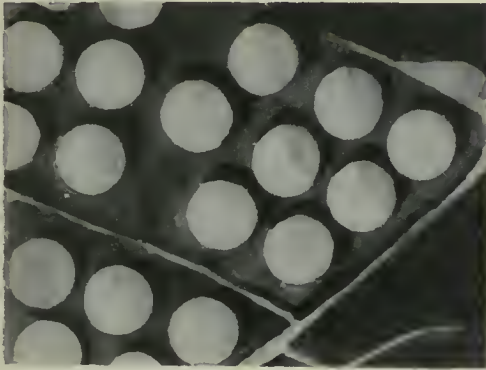
I- Tanks built underground.

INDUSTRIAL CAMOUFLAGE

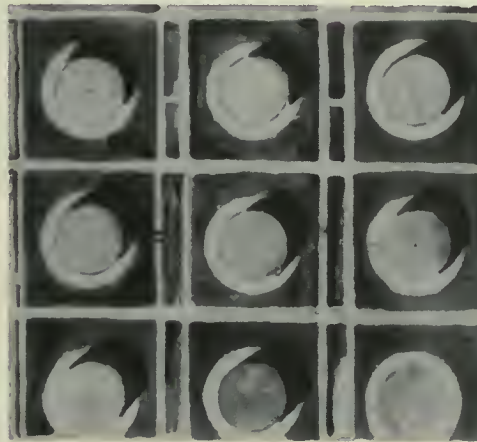
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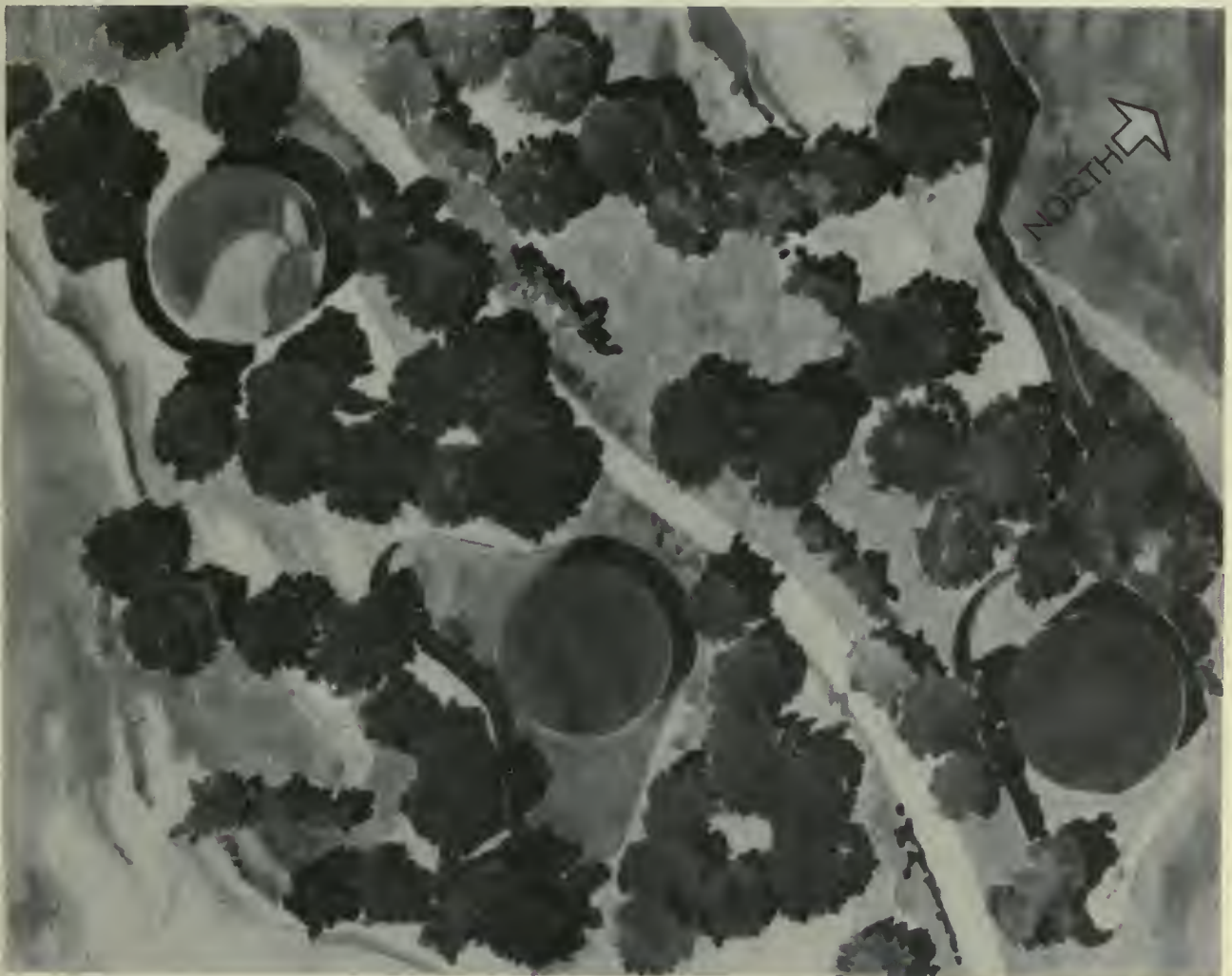
SUGGESTIONS FOR INDUSTRIAL CAMOUFLAGE DESIGN: DISPERSION OF TANKS



Dangerous congestion of tanks.
Thames Haven, England



Dangerous regularity of rows, roads, and pavements. Haifa, Palestine



Irregular setting of tanks, avoiding rows or regular shapes of embankments, makes a poor target. This design facilitates camouflage and blends well with rolling terrain. Embankment prevents spreading fire and conserves contents of the tank after damage to tank or pipelines.

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VARIOUS TYPES OF CONCEALMENT OF STORAGE TANKS



Different types of camouflage are used for concealment of cylindrical storage tanks.

- Tank 1, with light texture pattern on top, shows a conspicuous shadow.
- Tank 2, with painted pattern shows the shadow distorted by super-structures.
- Tank 3 shows shadow and roundness eliminated by nets sloping down from the top.

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SIGHT-PROTECTION WITH TREES
Oblique view of Model on page 98



The oblique view at an angle of 30° to 40° shows the effectiveness of trees to cover the shadowed sides of the tanks. All tanks are placed in embankments, the lines of which partly disappear under trees. Texture on top of the tank, and nets from the top to the edge of the embankment are most successful. The use of infra-red paint in matching spots may be advisable.

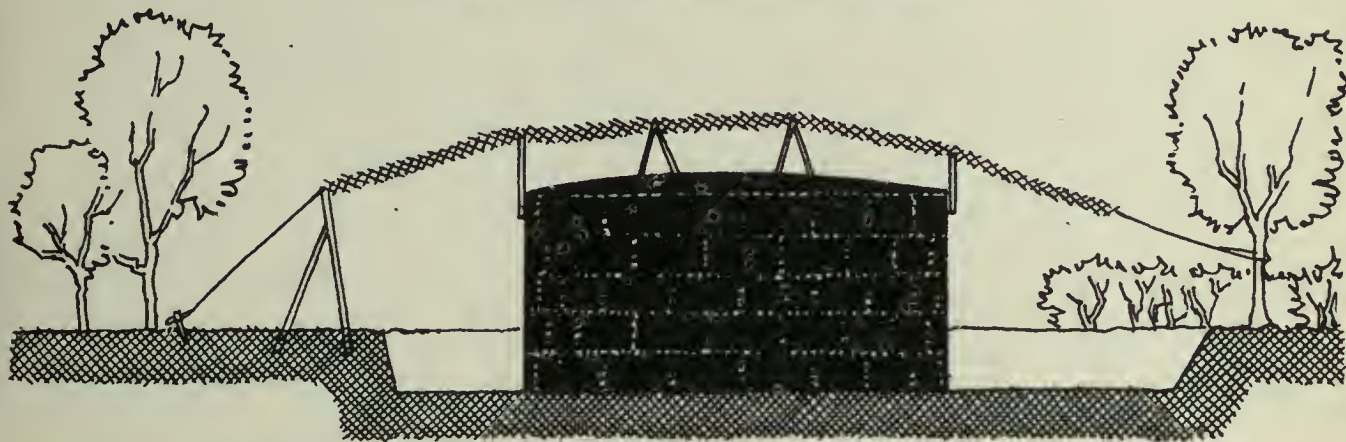
The fore-ground gives a section through the tank to show the embankment and the sloping nets.

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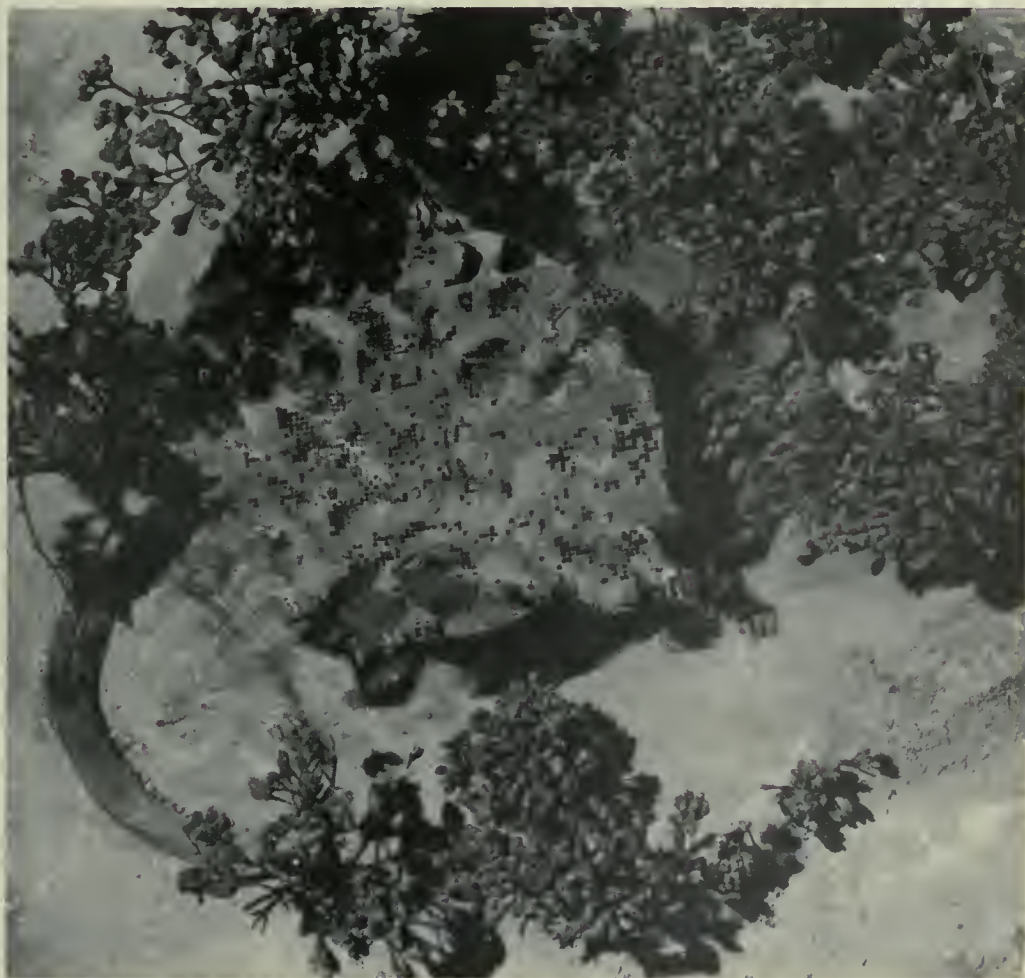
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CAMOUFLAGE OF STORAGE TANKS SHADOW CONFUSION WITH GARNISHED NET



Support the net with high poles in irregular setting and with additional props on top of the tank.



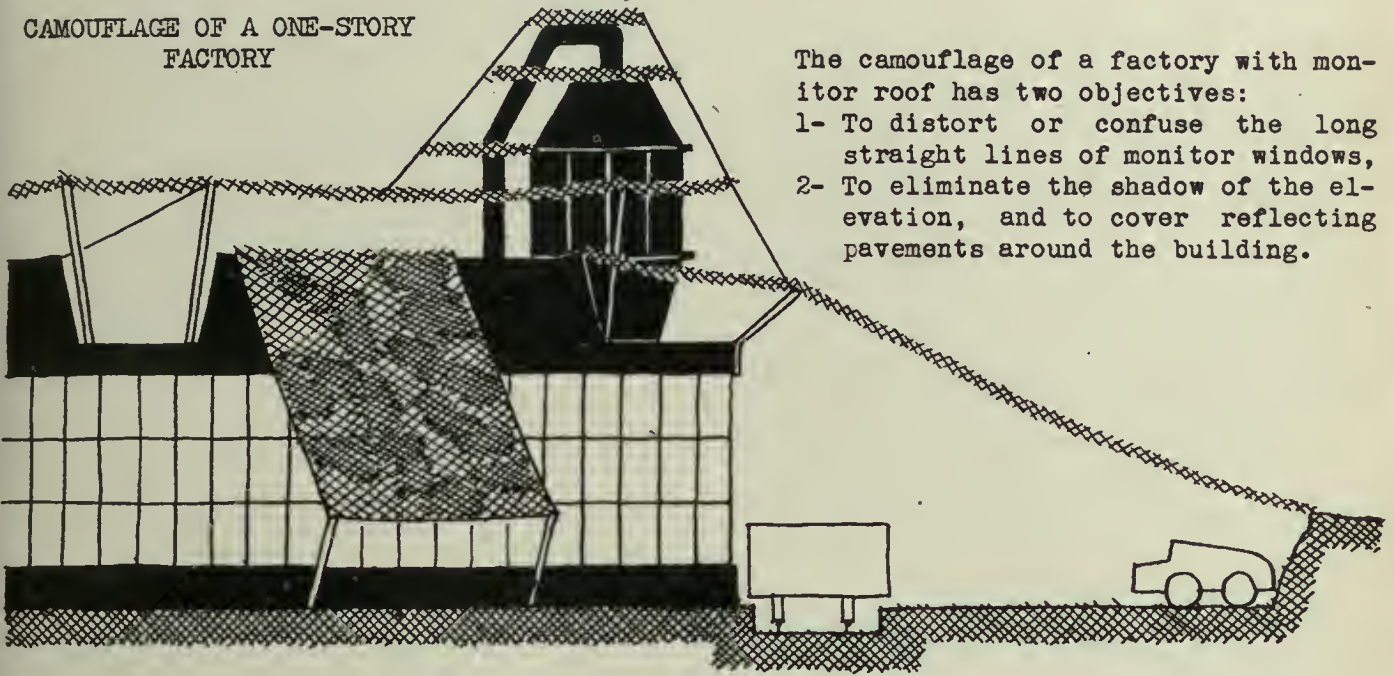
An average storage tank, 40 feet high and 100 feet in diameter, is a conspicuous target. Much more effective than painting the tank is to spread a thinly garnished net over the roof and to expand this net over the edge of the tank to cover or distort the shadow.

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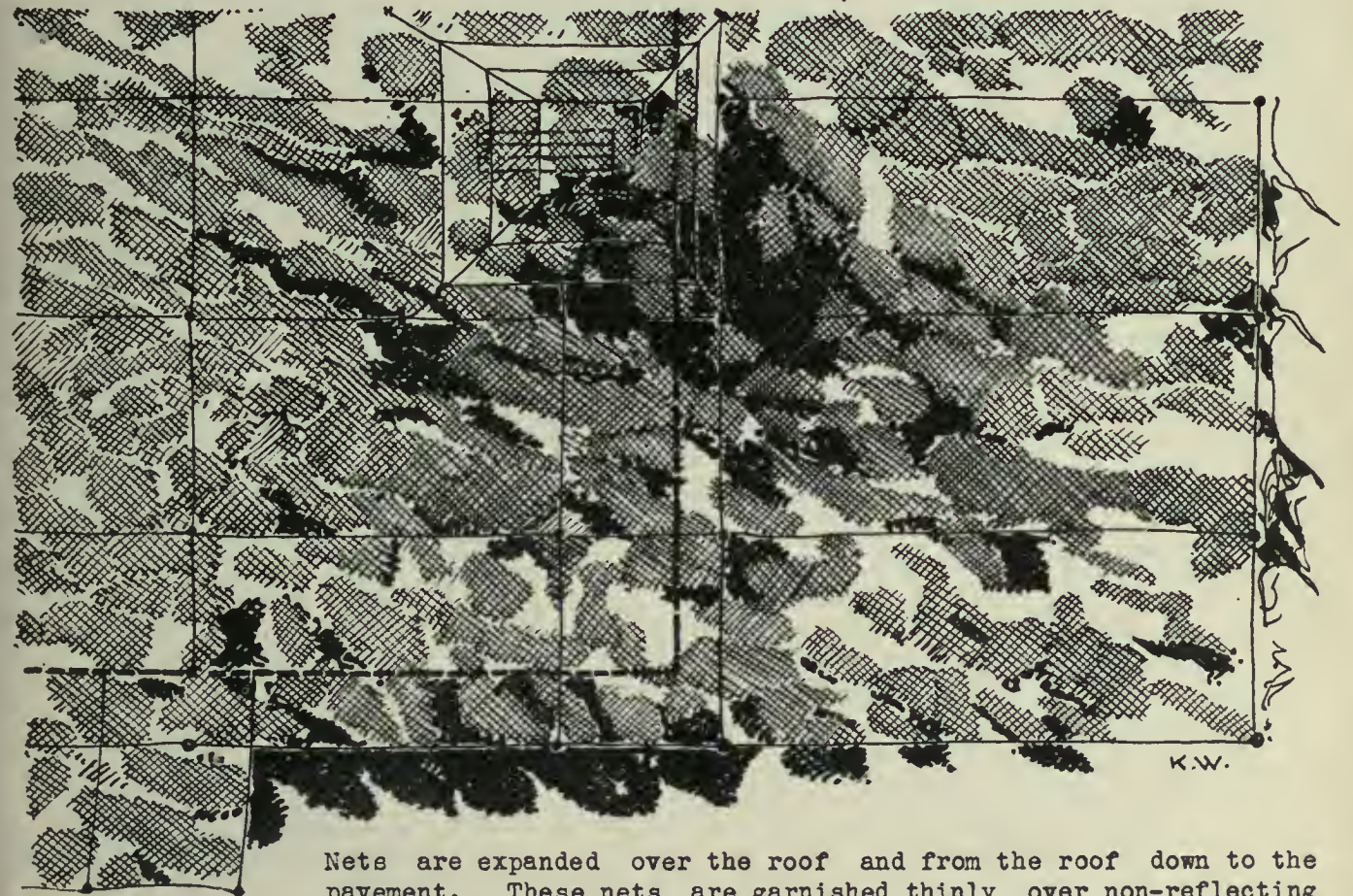
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CAMOUFLAGE OF A ONE-STORY
FACTORY



The camouflage of a factory with monitor roof has two objectives:

- 1- To distort or confuse the long straight lines of monitor windows,
- 2- To eliminate the shadow of the elevation, and to cover reflecting pavements around the building.



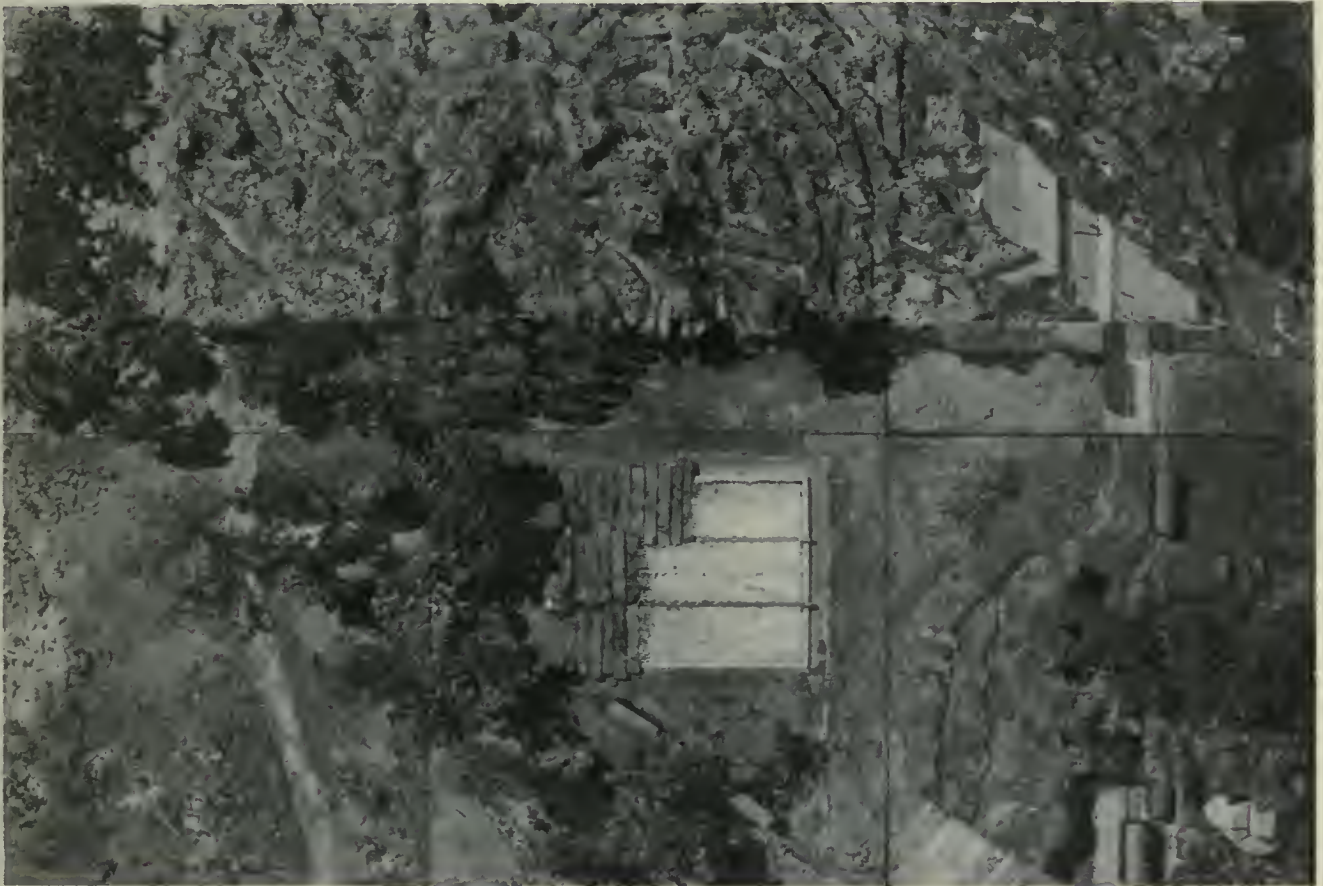
Nets are expanded over the roof and from the roof down to the pavement. These nets are garnished thinly over non-reflecting and flat parts of the roof, but thickly where reflective surfaces or moving vehicles are underneath.

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VARIOUS TYPES OF CONCEALMENT FOR
CAMOUFLAGING AN INDUSTRIAL AREA



The model demonstrates different requirements and types of camouflage used simultaneously to conceal a big factory and adjacent industrial structures:

- 1 The roof is covered with a garnished net, or series of nets, built partly on one level and partly on two levels. Additional nets, imitating trees, cover superstructures on the roof (exhausts and vents). These nets project over the edge of the roof enough to protect against recognition from low angles; if possible, they are sloped down to cover adjacent pavements.
- 2 The silo building has a similar arrangement of nets, but expanded in several levels to overcome the considerable height of the structure.
- 3 The adjacent railroad siding is covered with a solid, curved roof and, partly, with horizontal nets.
- 4 The spray pond is covered with boards on prepared beams. Very light fibre-board is used to facilitate quick installation and removal.
- 5 Railroad siding near this pond shows the advantages of an open layout with tracks sufficiently separated and concealed by trees.
- 6 The parking field (upper left) is designed in curves to provide a fixed location for every car and to use existing trees for cover.
- 7 The model shows advantages of trees to an industrial area; it is easier to design a camouflage pattern if the terrain invites imitation.

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COVERING REFLECTIONS AND ELEVATIONS



A corner of the one-story factory with monitor roof before and after camouflage. The flat surface of the roof is easily treated, but the reflecting windows and the shining exhaust need special consideration. The net is placed high enough so that a man standing on the roof can reach it easily. All reflecting metal surfaces should be painted dark, as indicated on one side of the exhaust.



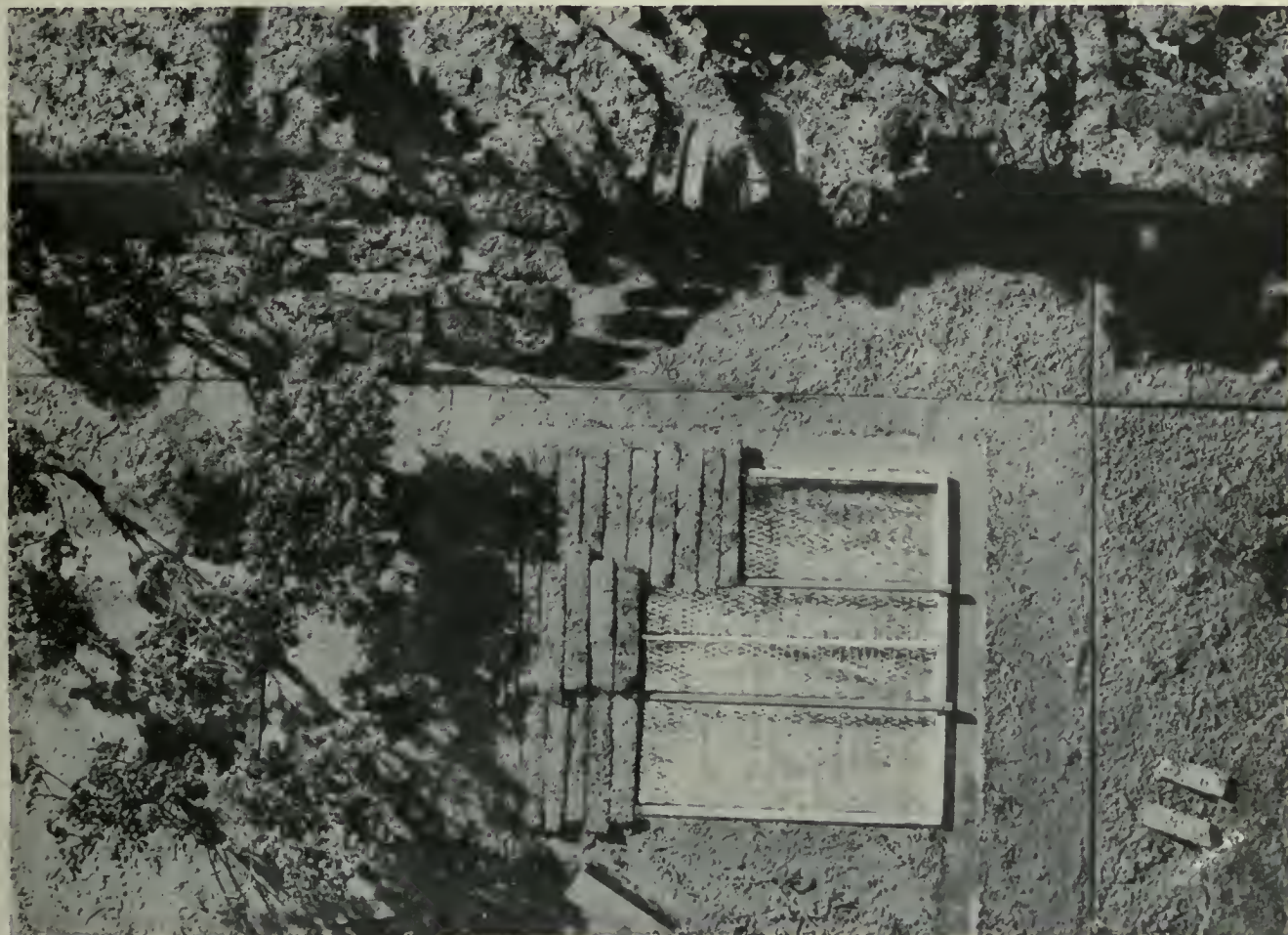
The net is sloped down to cover the parked cars.

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COVERING WATER SURFACES



An open water surface near a factory, especially a surface of regular shape like a spray pond, a rectangular swimming pool or a reservoir provides a great help for orientation. Water reflects not only sun rays and moonlight, but even the lustre of starlight. It is equally defined on cloudy nights. Cork, soot, or black sawdust are suggested for camouflage, but it is difficult, if not impossible, to control floating substances. Water currents, wind, and rain disperse or amass floating particles. Re-use of polluted water is very often impossible. It is therefore better to cover the water with nets or mats of reed on expanded wires, or with movable boards on stationary or floating beams. Woodfibre boards (like Thermax boards) are more advisable than wooden boards because of their lighter weight, their natural tendency for patina, and the absence of gloss when wet.

The photograph shows shadow confusion with nets sloping down from the roof and the obliterating effect of the fringed edge - an effect which is designed against observation at a great distance.

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TEXTURE PATTERN OVER MONITOR ROOF
PARKING AREA UNDER TREES



This close-up shows that the texture is "painted" with shadows and not with paint. Careful study of the surrounding terrain is necessary to define this texture pattern which may be a pattern of rough grass, shrubs, barren earth, or stones and rocks. The flow of the pattern has to correspond to the main figuration of the landscape, preferably not parallel to the parallel lines of the roof. This net is built in two levels to avoid the monotony of a flat expanded surface.



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IRREGULARITY OF PATTERN AND SHADOW CONFUSION



Section through one-story factory, showing monitor roof, arrangement of nets, and oblique view of camouflaged silo.

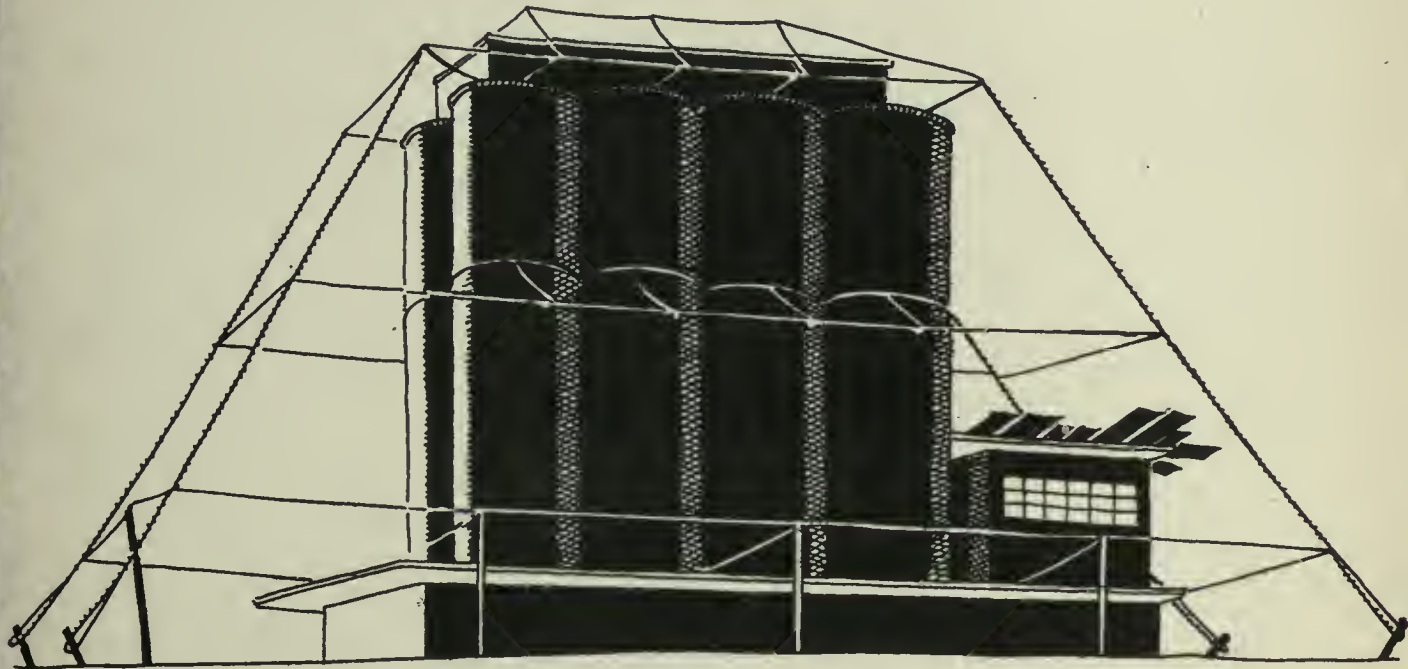
No attempt is made to place the poles in regular rows, or to have rectangular nets neatly arranged. On the contrary, the supporting wires criss-cross the roof in an irregular fashion and the nets are not all of the same size. They vary in shape, mesh, and garnishing, to produce greater variety in texture. Part of the net (the center) is purposely omitted.

The silo building is surrounded by nets, but not with the purpose of eliminating the shadow completely. The shadow is reduced and the remaining shadow deformed.

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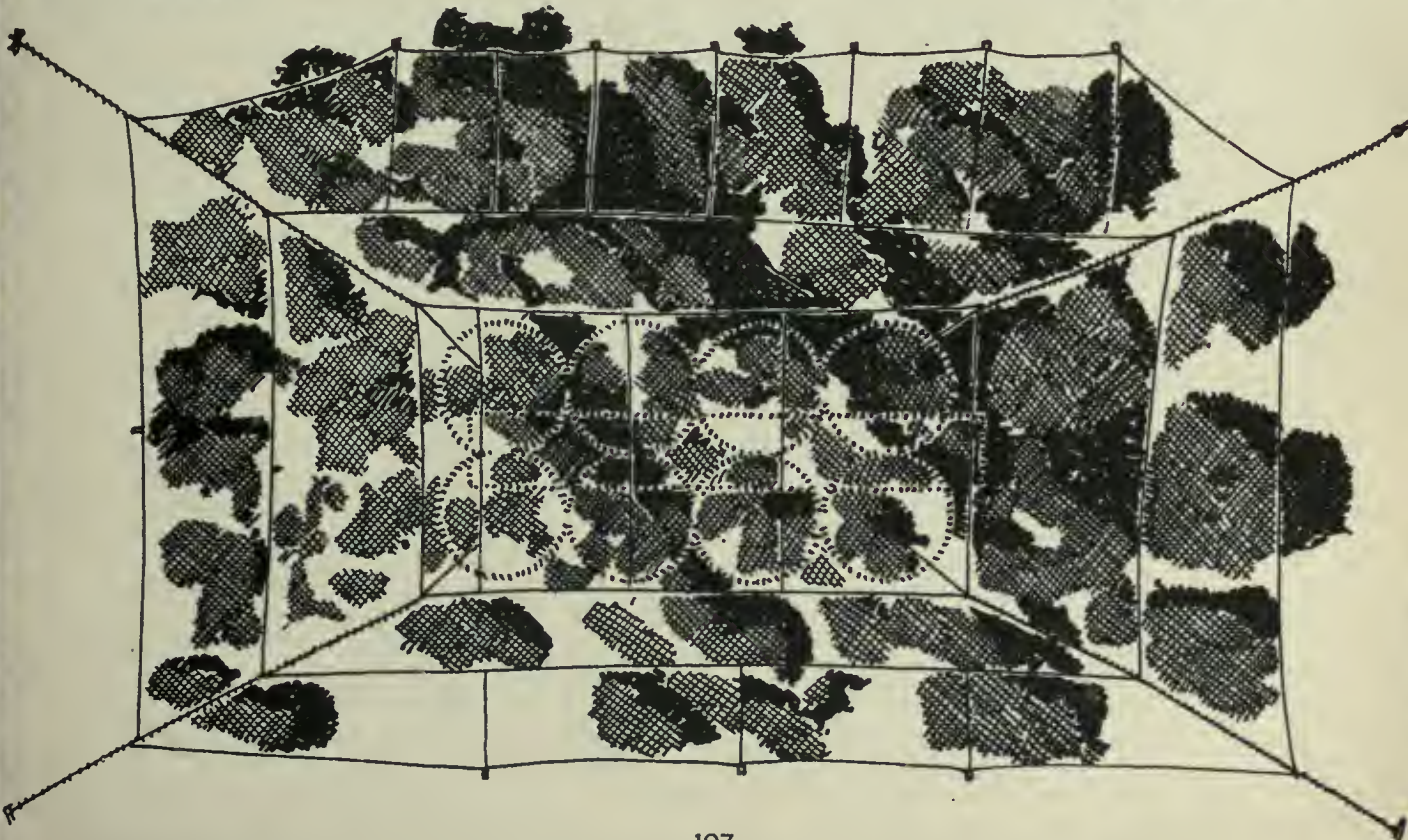
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Camouflage of an elevator or silo uses a system of nets in varying levels, expanded between cables from the top to the ground. These nets are not flat but more or less sloping downward, to reduce the considerable height of the silo. They produce a confusing, smudgy shadow of the structure, or, if advisable, a definite shadow which imitates high trees. Parts of the net could hang down vertically.

CAMOUFLAGE OF A
GRAIN ELEVATOR



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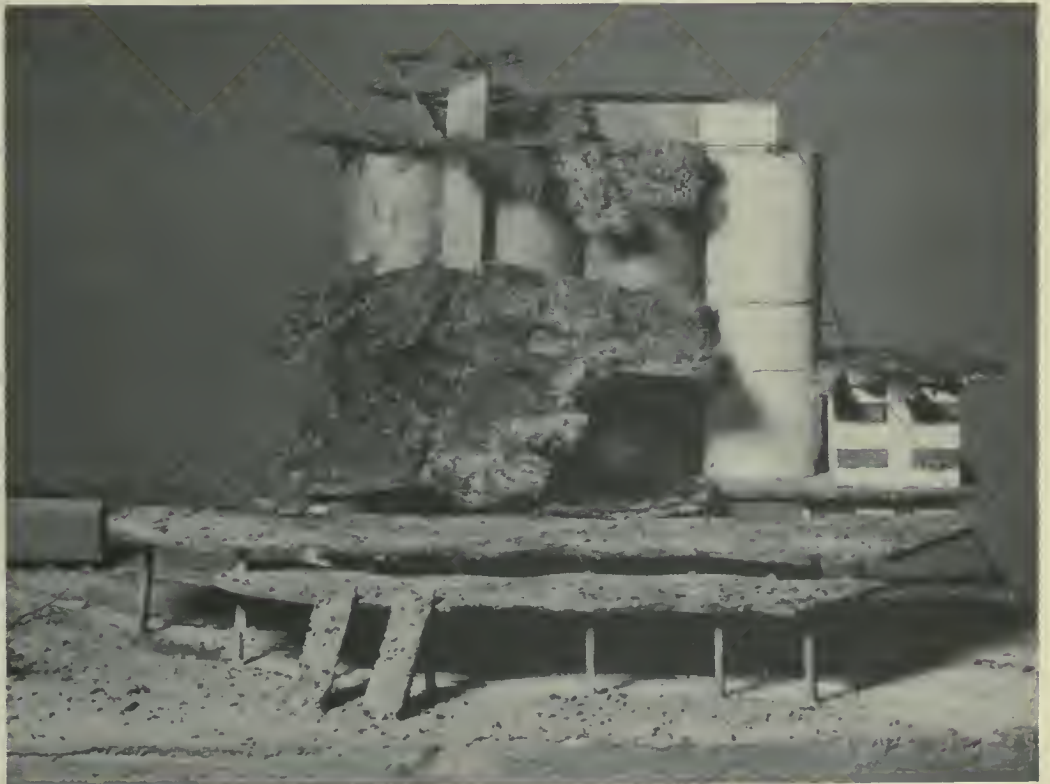
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CAMOUFLAGE OF A GRAIN ELEVATOR SHADOW REDUCTION IN THREE LEVELS



An oblique view of a partly camouflaged model of grain elevators. The textured nets are expanded in three levels, the nets sloping down or hanging to cover the elevation. The building itself is painted dark gray, but not black, with elimination of white reflections. Part of the model purposely uncamouflaged.

The railroad siding in the foreground has two roofs at different levels, with rough planks covered with texture.

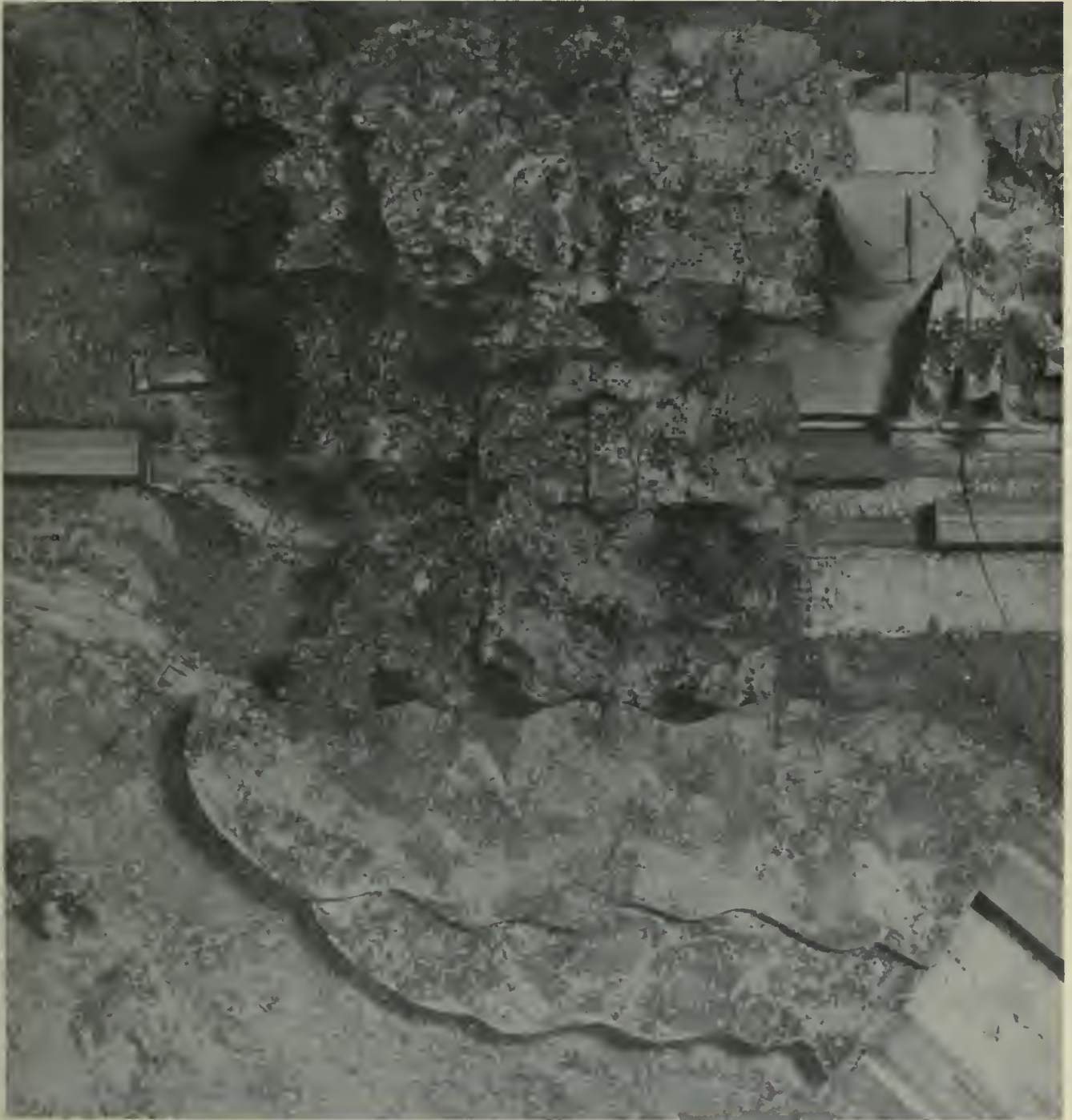


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CAMOUFLAGE OF A GRAIN ELEVATOR
A MUDDLED AND UNCERTAIN TARGET



The vertical view explains how the straight and conspicuous shadow is dissolved into a meaningless pattern of smaller shadow-spots. Choice of texture material depends upon whether or not it should blend with the ground or stand out with definite contour as a group of trees.

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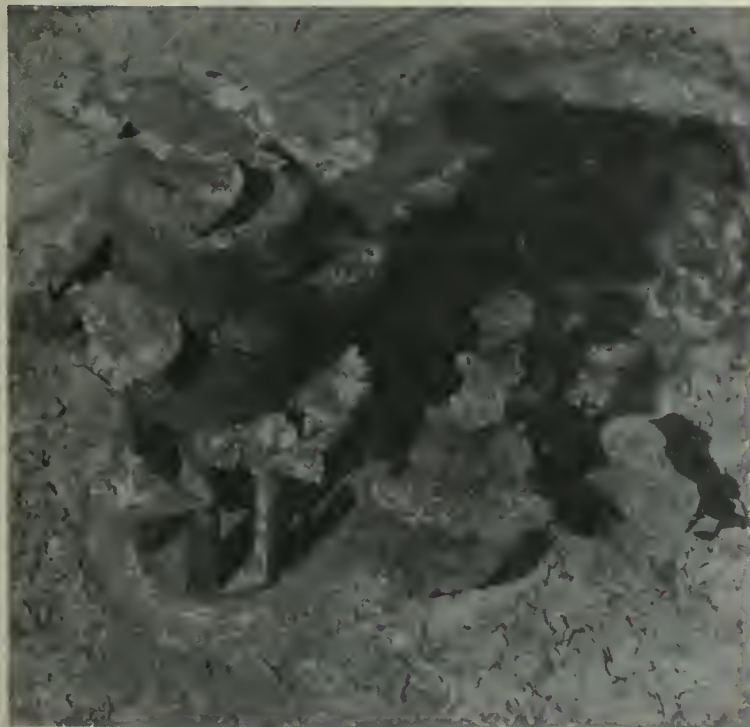
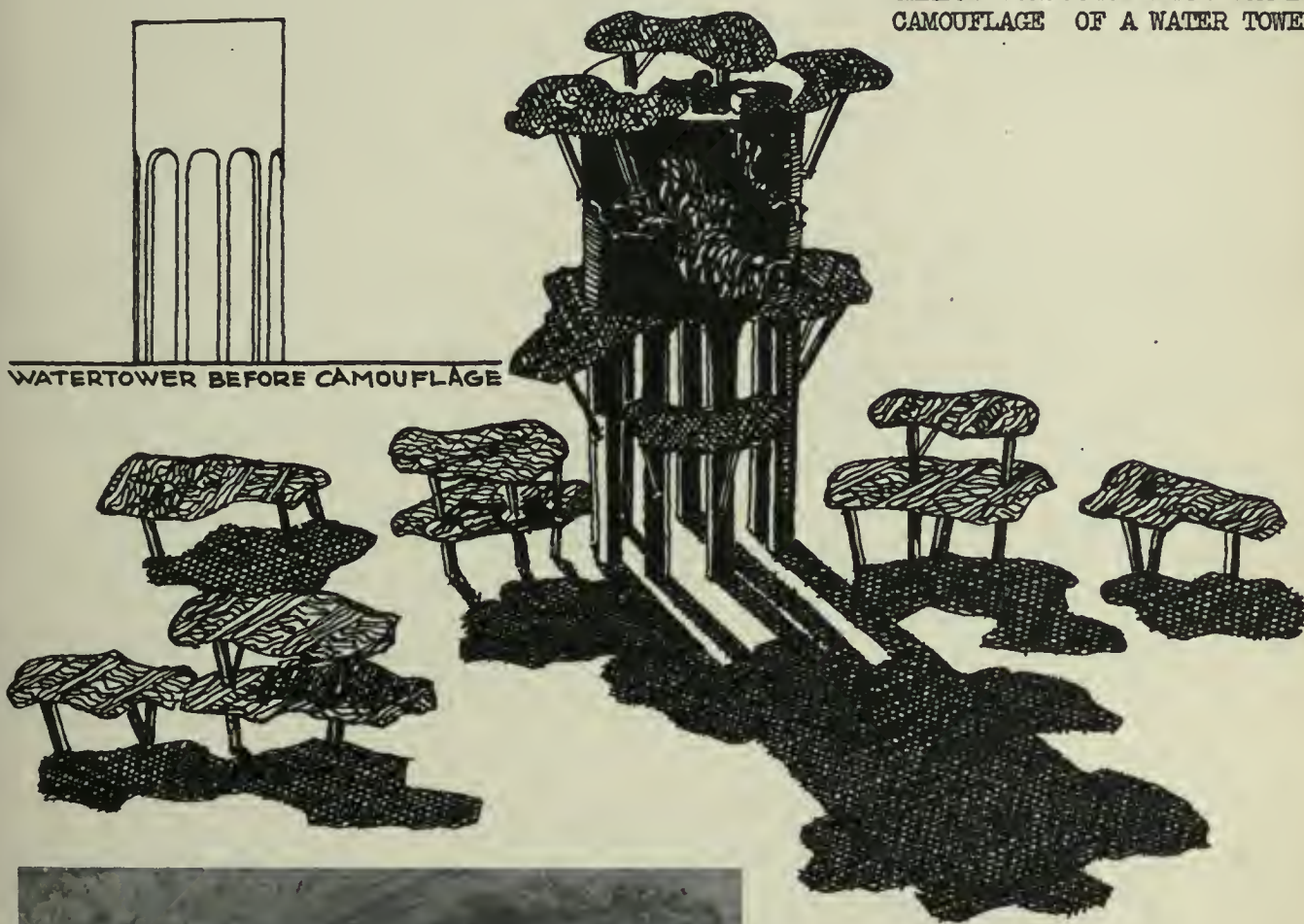
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SHADOW CONFUSION WITH BOARDS
CAMOUFLAGE OF A WATER TOWER



WATERTOWER BEFORE CAMOUFLAGE



Protection of watertowers is very often quite as important as supply of munitions. The round form is very conspicuous. If watertowers stand in woods or between trees (as do many watertowers on Long Island) it is comparatively easy to fake a group of tall trees. Isolated watertowers can be equipped with projecting slabs at various heights to divide (or optically reduce) the height, create confusing shadows, and change the vertical form into a broad, horizontal form.

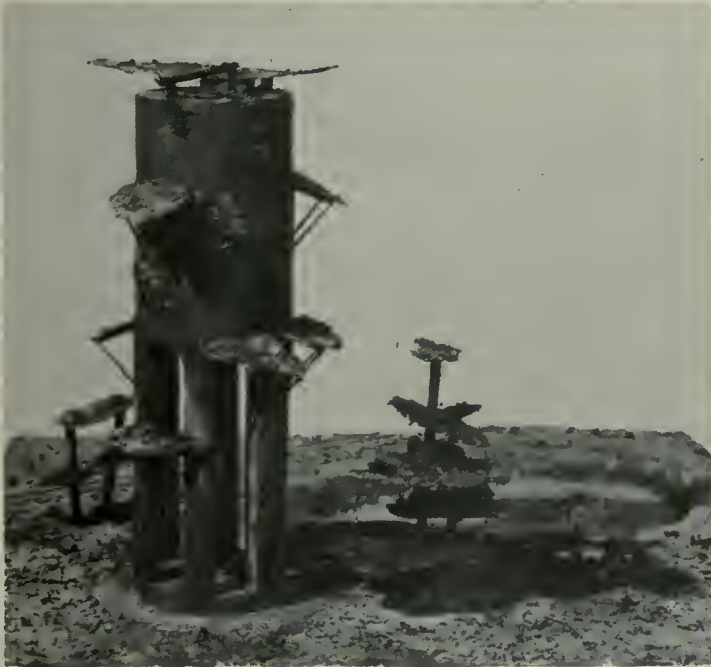
Water towers of steel construction can use cantilever angles and rods screwed to the structure, with wire mesh or expanded metal slabs, filled in or sprayed with mastic compound.

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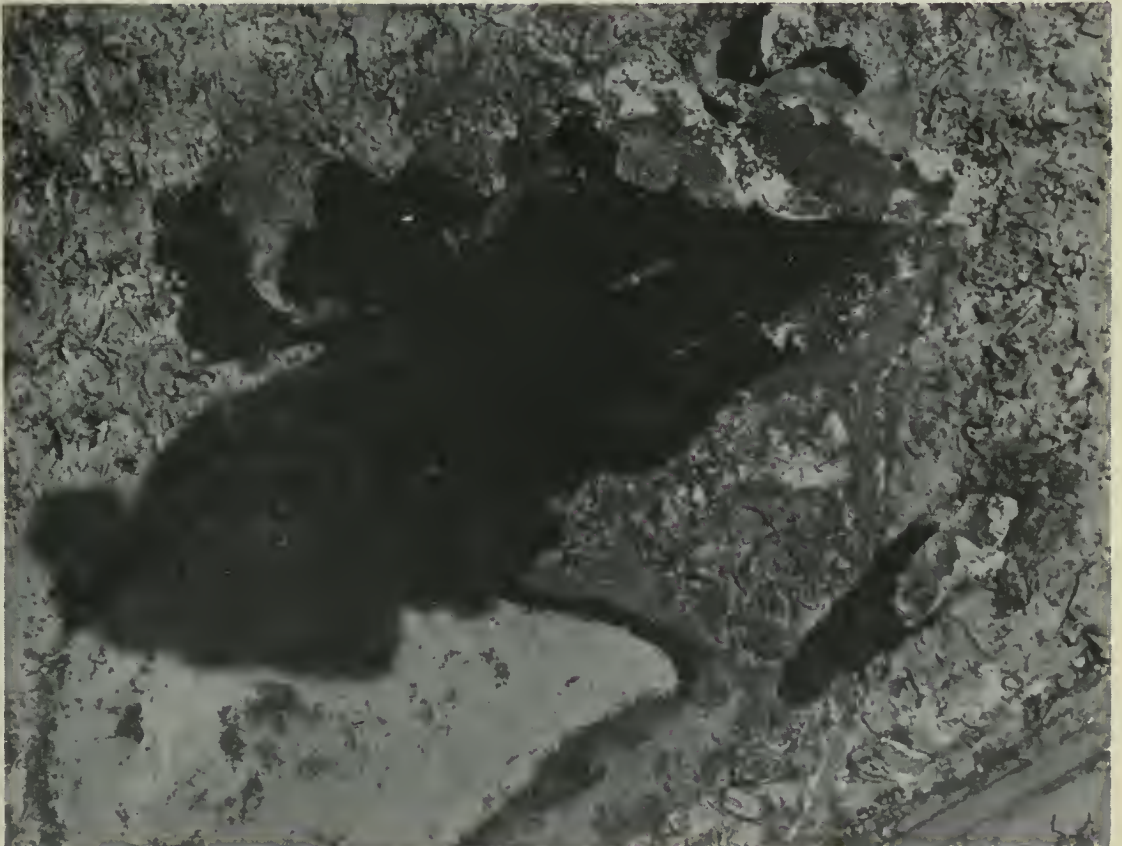
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TEXTURE AND ARTIFICIAL TREES DISTORT THE CONSPICUOUS ROUNDNESS



A few boards or panels are placed on top of the watertower to distort the circular shape. In order to make these superstructures light they are constructed in wood with some fiberboards, e.g. thermax boards. For the projecting slabs we can use the same material, supported by simple carpenter constructions. These slabs are placed at different levels. The shadow effect resembles the shadow of a tree.



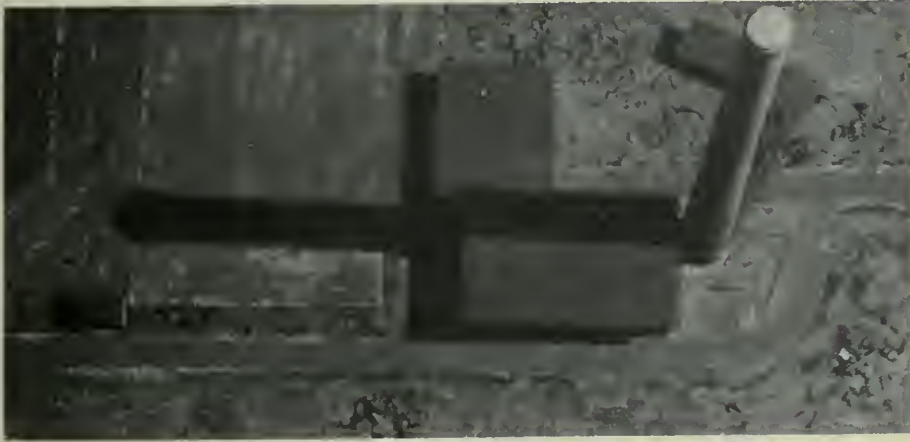
Artificial trees made of the same boards help to broaden the shadow.

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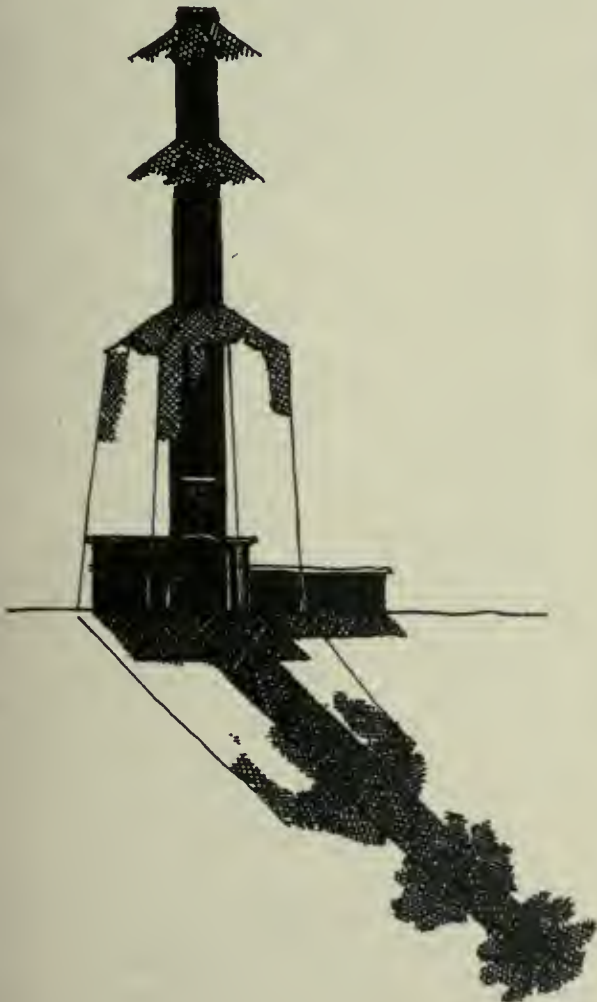
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CONSPICUOUSNESS OF A CHIMNEY: VERTICAL REFLECTIONS AND STRAIGHT SHADOW



The purpose of the installation is to confuse the bombardier. It is admitted that stereoscopic pairs might make the location apparent in an aerial photograph.



Before adding any vertical load to the chimney and increasing the stress in the brickwork, it is necessary to investigate the actual and allowable working stress in the brickwork.

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CAMOUFLAGE OF A CHIMNEY - THE UMBRELLA METHOD I



The umbrella method cuts the height of the chimney into smaller sections, partly covering the vertical line against recognition at an angle of 30° to 45° .



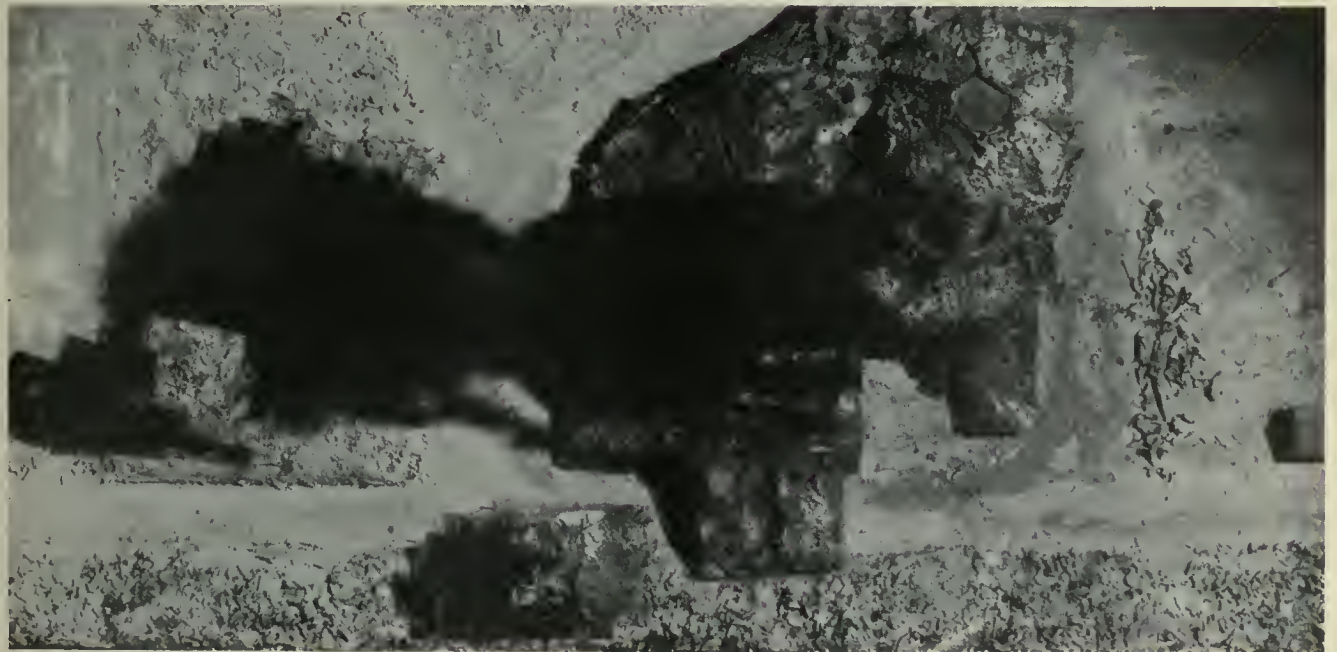
Two or more umbrellas can be placed on a chimney by circling it with two cables for each umbrella, the cables being fastened with cable clips and supplemented by an outstanding structure of the patent scaffold type, guyed diagonally if necessary. The umbrellas may extend 10' to 25', irregular in shape, and covered with textured, impregnated chicken-wire. The texture must not be so dense as to cause tension under wind pressure. Tests of the weight of garlanded chicken-wire, wet, or wet and frozen, seem to indicate that it would be safe to design for about 1 lb. per sq. ft.

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CAMOUFLAGE OF A CHIMNEY - THE UMBRELLA METHOD II



Improved application of the umbrella method, with nets, very thinly garnished, hanging from the umbrellas. Vertical wires hold these chicken-wire nets in place. This arrangement reduces reflections on the vertical shaft better. Artificial trees on the ground introduce more confusing shadows to blend with the distorted shadow of the chimney.

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CAMOUFLAGE OF A CHIMNEY - WITH CABLES AND NETS



At several points in the height of the chimney, encircling cables can be installed and guy cables run out to "dead men" set in concrete footings. The nets would be garnished chicken-wire with intermediate support if necessary of heavy-gauge soft iron wire.



The wind pressure on the nets must be added to the normal overturning moment of the wind on the chimney. This normal pressure on the chimney is commonly figured at 20 lbs. per sq. ft. It may be necessary to equalize the pull of the cables so that only a vertical load is transmitted to the chimney.

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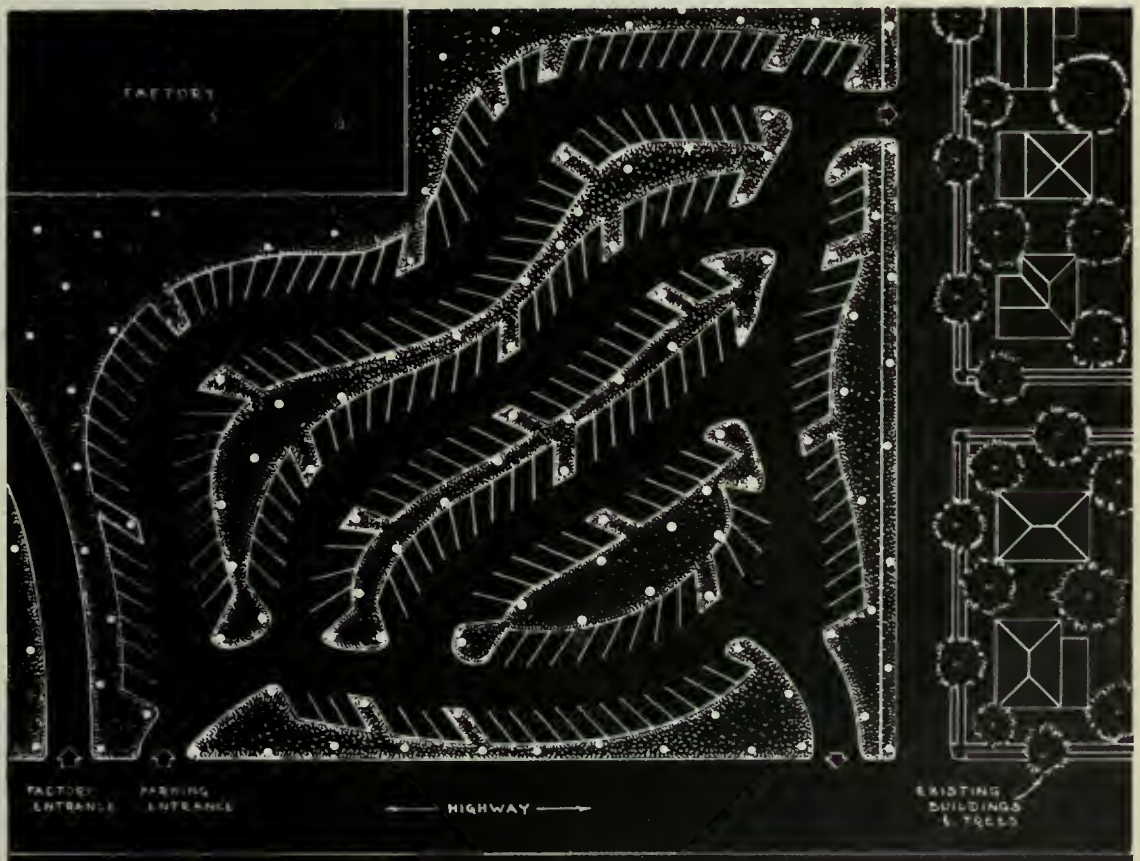
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PARKING AREAS - A NEW DESIGN PROBLEM



The design of parking fields has been, until now, only a problem of two-dimensional design. Parking in straight lines on wide-open fields was considered the only practical way, using the available space to the limit, with only as much allowance as absolutely necessary for driving and backing. Big car-parks with long lines of parked cars easily expose the industrial locality.

Safer design in arranging parking fields uses decentralization and dispersion into several smaller fields as a most necessary measure to reduce conspicuousness. The next step is dispersion within the smaller field itself, providing more open spaces.

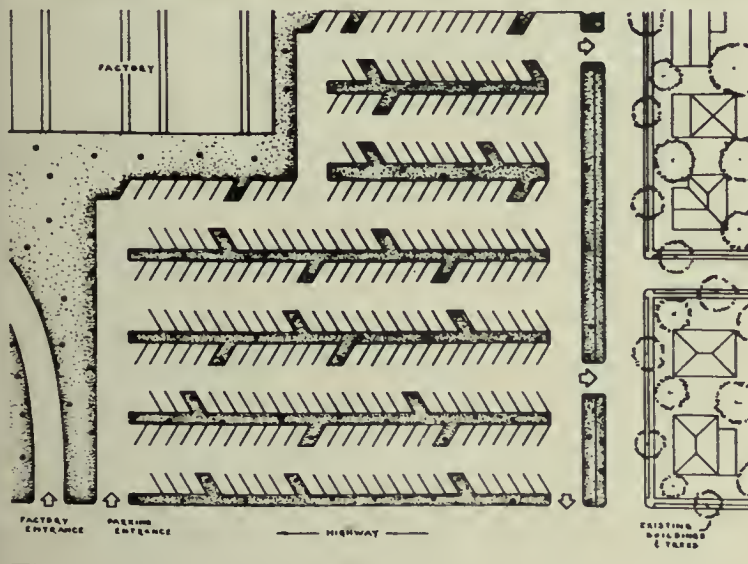
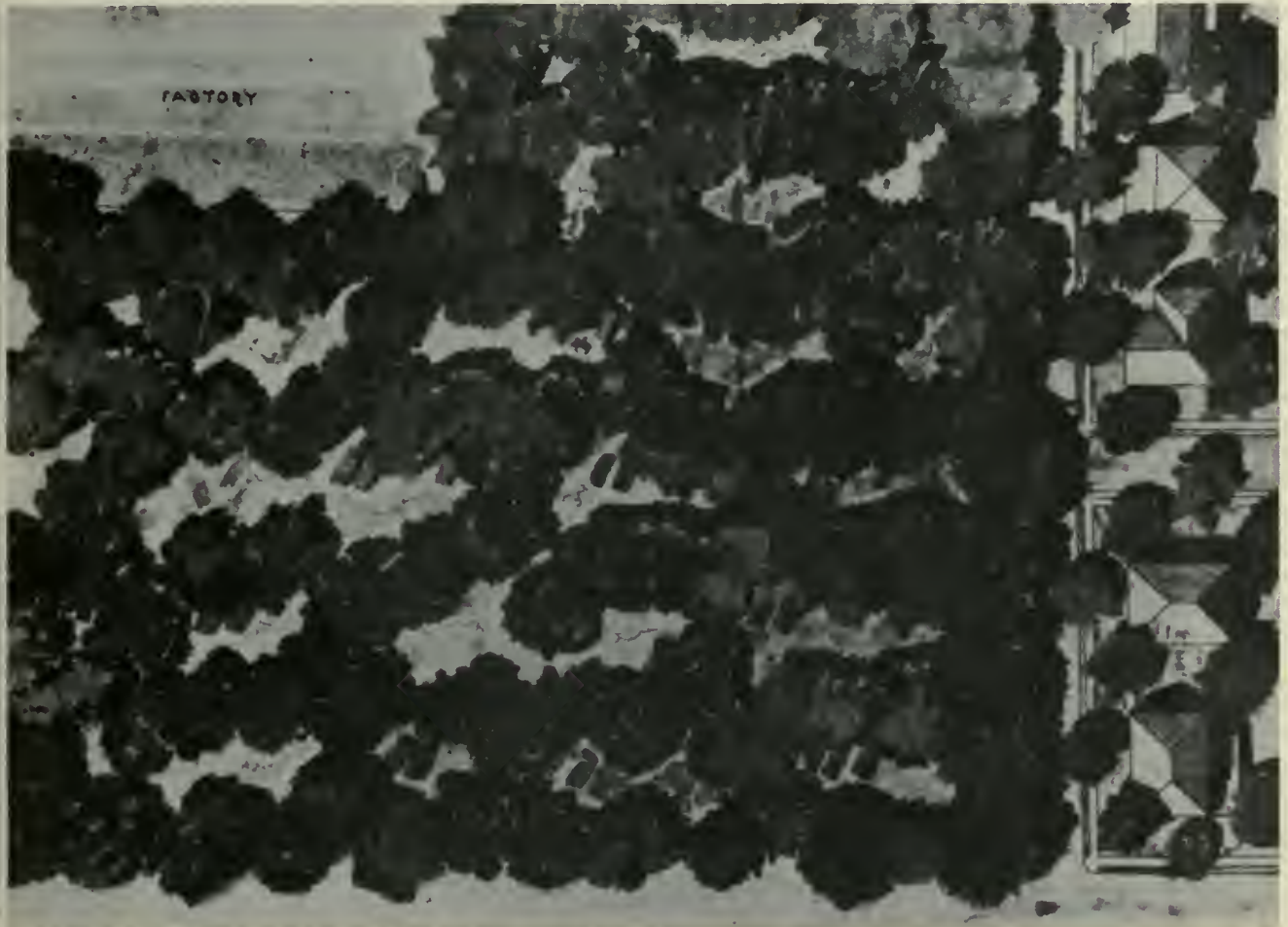


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DESIGN SUGGESTION FOR PARKING FIELD I



Design Suggestion #1

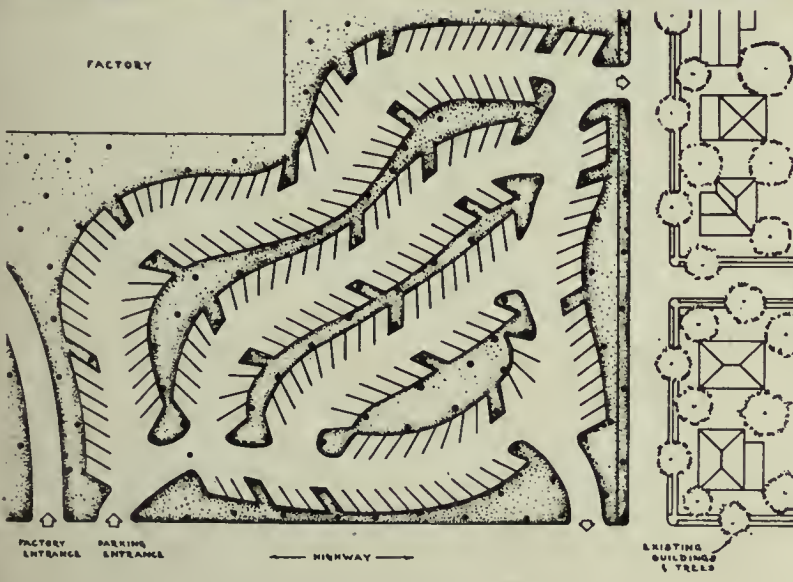
The aerial view shows trees to be the best and cheapest means of concealment considering the probable angle of recognition. Trees on parking fields, however, should be so placed as to avoid long, even rows. This is accomplished by a special arrangement of the separating strips of grass. The assignment of parking space should be planned with the consideration that all cars with common destinations are parked together.

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DESIGN SUGGESTION FOR PARKING FIELD II



Design Suggestion #2

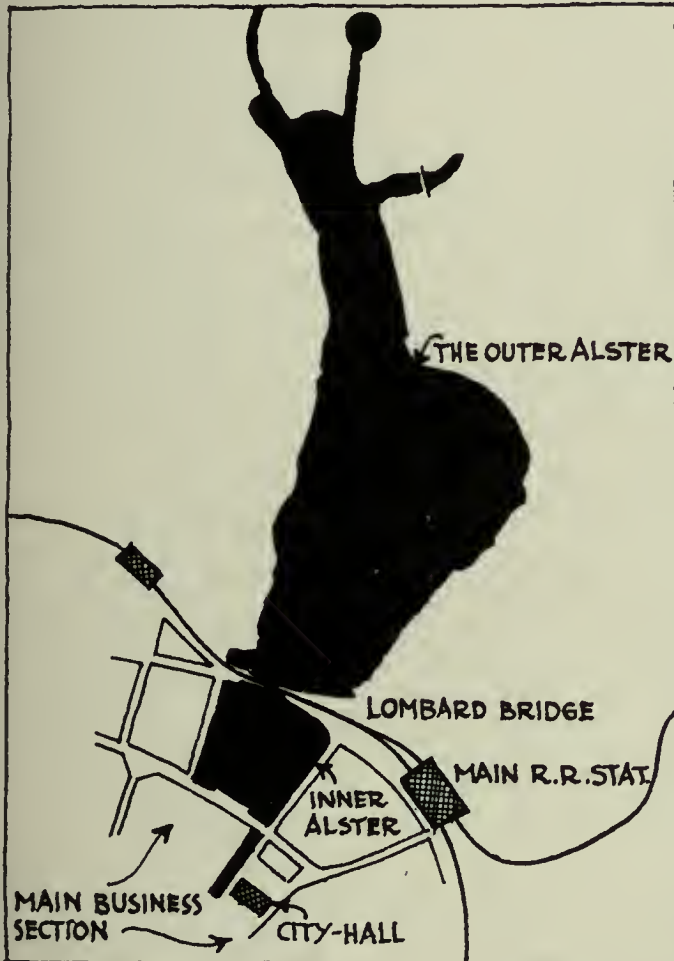
The problem is to distribute trees in such a way that the group looks like a natural wood or grove. This design solves the problem with curved routes and a very free arrangement of trees. A similar layout will be necessary if cars are parked in an existing wood.

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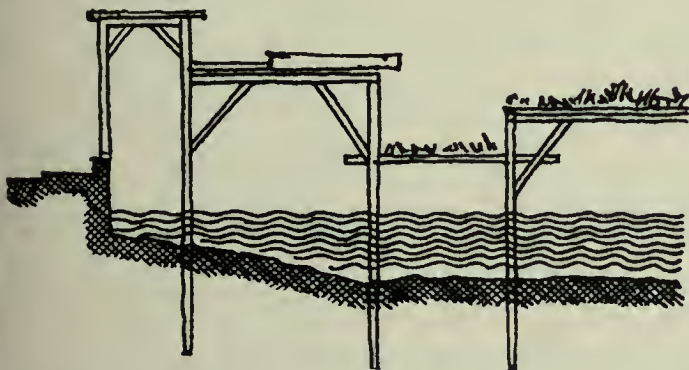
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CAMOUFLAGE OF THE ALSTER BASIN IN HAMBURG



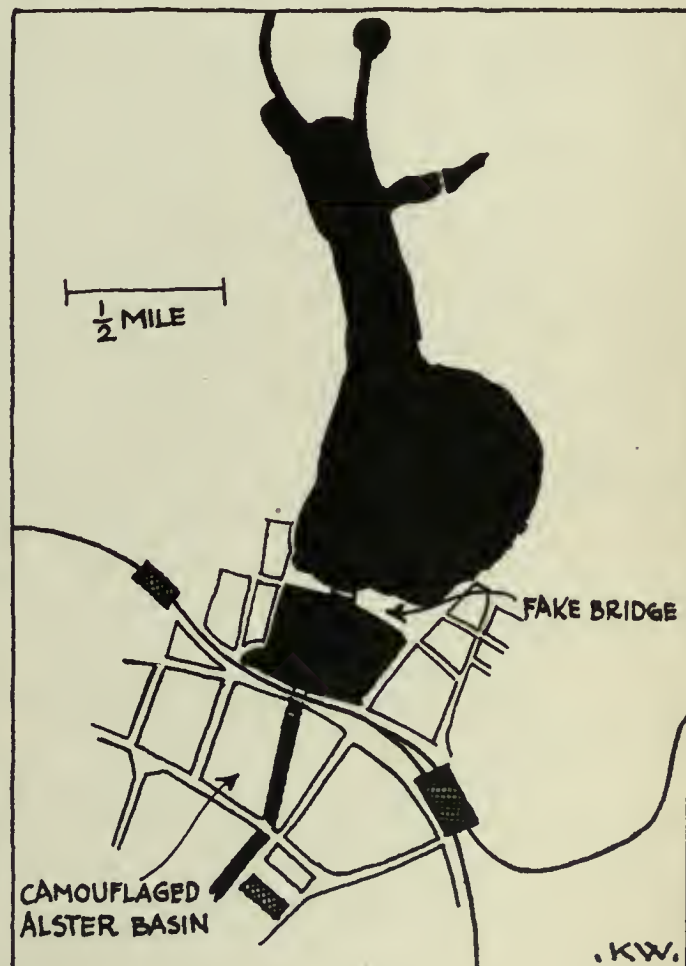
The Alster Basin in Hamburg, in the heart of the city, is one of its famous sights, center of business and social life. The Lombard Bridge, a very important traffic artery, divides the Alster Basin into a smaller, almost square part called the "Inner Alster" and a much larger part, the "Outer Alster".

The regular square of the Inner Alster made orientation in night raids easy. Therefore the whole area, about 2,000 to 2,200 ft., has been covered with boards and nets with textured material, representing several city blocks. A fake bridge has been built at a proper distance, with imitation railroad tracks and dummy cars.



Hundreds of poles have been driven into the soft ground of the basin to erect these fake constructions. It took four months to build these camouflage structures - from January, 1941 to April, 1941.

Drawn from English aerial Photographs and eye-witness reports.



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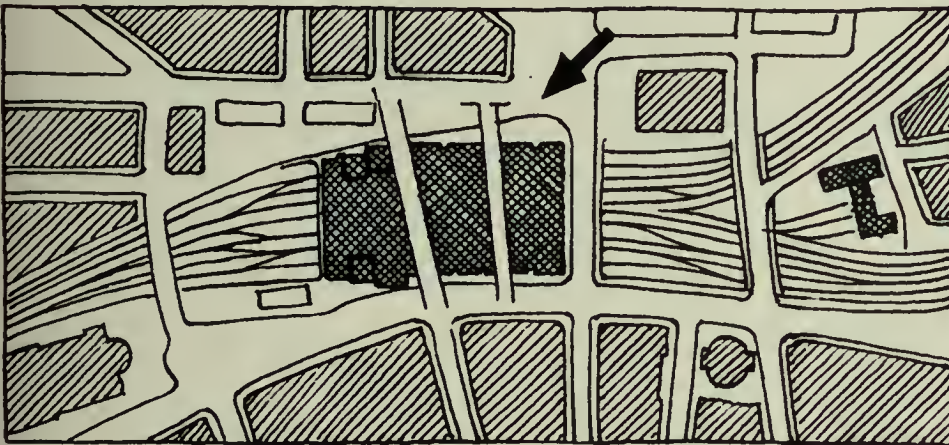
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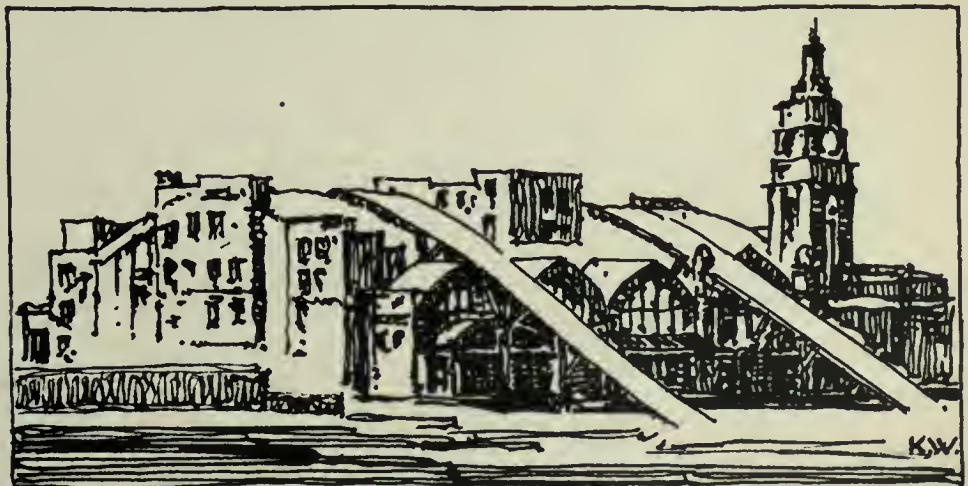
CAMOUFLAGE OF THE RAIL-
ROAD STATION IN HAMBURG

The main railroad station in Hamburg has a vaulted roof of enormous dimensions. Bigger than any adjacent structure, and constructed entirely of steel and glass, it stands out dominantly with broad reflection.



The great south window, 300 feet wide, is covered and painted to represent a row of houses. Two fake streets cross the roof with ramps of boards, over-bridging the station plazas, to create continuous white lines.

Sketch of the camouflaged railroad station from the south - east, indicating the crossing street-ramps as revealed by English aerial photos and eye-witness reports.

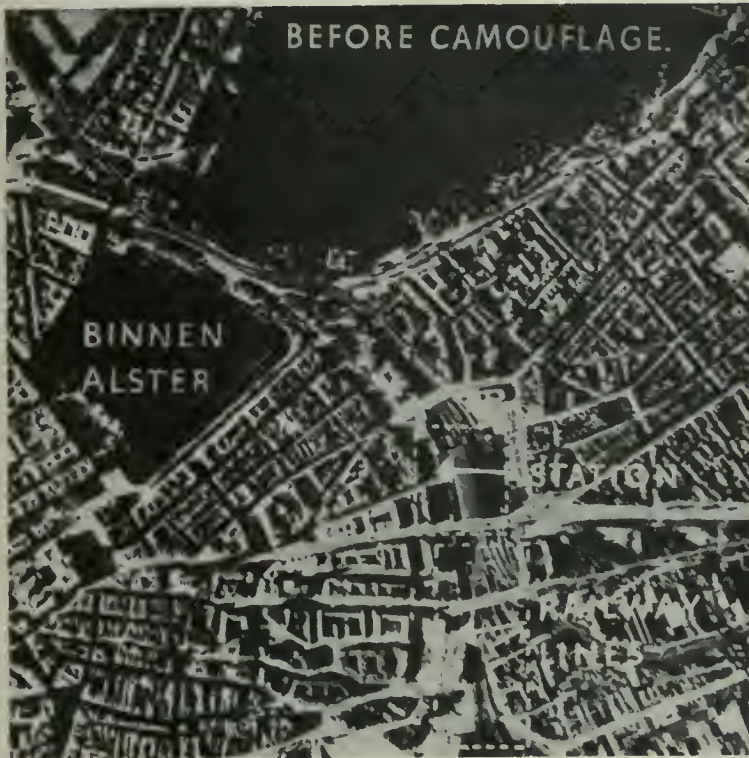


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HAMBURG CAMOUFLAGE IN AERIAL PHOTOGRAPHS



The port of Hamburg has, in addition to the river Elbe, much open water, docks, and port facilities but none, within the boundaries of the town, so characteristic as the Alster Basin. Its length, orientation, and definite shape, help the bombardier in aiming at the business center of the city.

The two English aerial photographs are taken at different months, which accounts for differences in the shadow pattern, especially visible on the roof of the railroad station. The "after" photograph was taken early in spring 1941 when trees were still without foliage.



Note that the pattern of the faked city blocks is generally too bold and lacks detail, showing flat roofs instead of the detailed pattern of pitched roofs in this, the very oldest part of Hamburg. The false bridge, 1,000,000 sq. ft. in size, is dull and flat in appearance, too definitely contoured, and with not enough texture. The depth effect of shadow is lacking.

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FIVE PAGES WITH A TYPICAL REPORT FOR CAMOUFLAGING A FACTORY

1

Principal design for the camouflage scheme; general consideration for the pattern of the installation, with comparison of shadow effect before and after.

2

Condensed report in regard to visibility and vulnerability, with suggestions for the landscaping program, the camouflage program and for plant organization and management in times of emergency.

3

4

Construction outline for the camouflage superstructure.

5

Estimate of cost.

For the purpose of simplicity an average factory installation has been assumed. It does not include the problem of blackout. The location represented would be south of New York City, but not in an area subject to high winds. In northern climates, subject to heavy snow and alternate thawing and freezing, the allowance of one lb. per sq.ft. for live and dead load of garlanded wire might have to be increased to a possible maximum of 20 lbs. per sq. ft. This would increase the necessary strength of the rest of the structure. Light assumed loads can be used only in areas of light frost and where provision is made to remove manually any ice formation.

The cost would naturally vary depending upon whether the job was done by army personnel, regular plant staff, or local union labor. Ventilation changes, the necessary substitution of non-priority material, and many other special problems would also affect the cost. The estimate given herein is meant to indicate only the approximate order of magnitude of the expense.

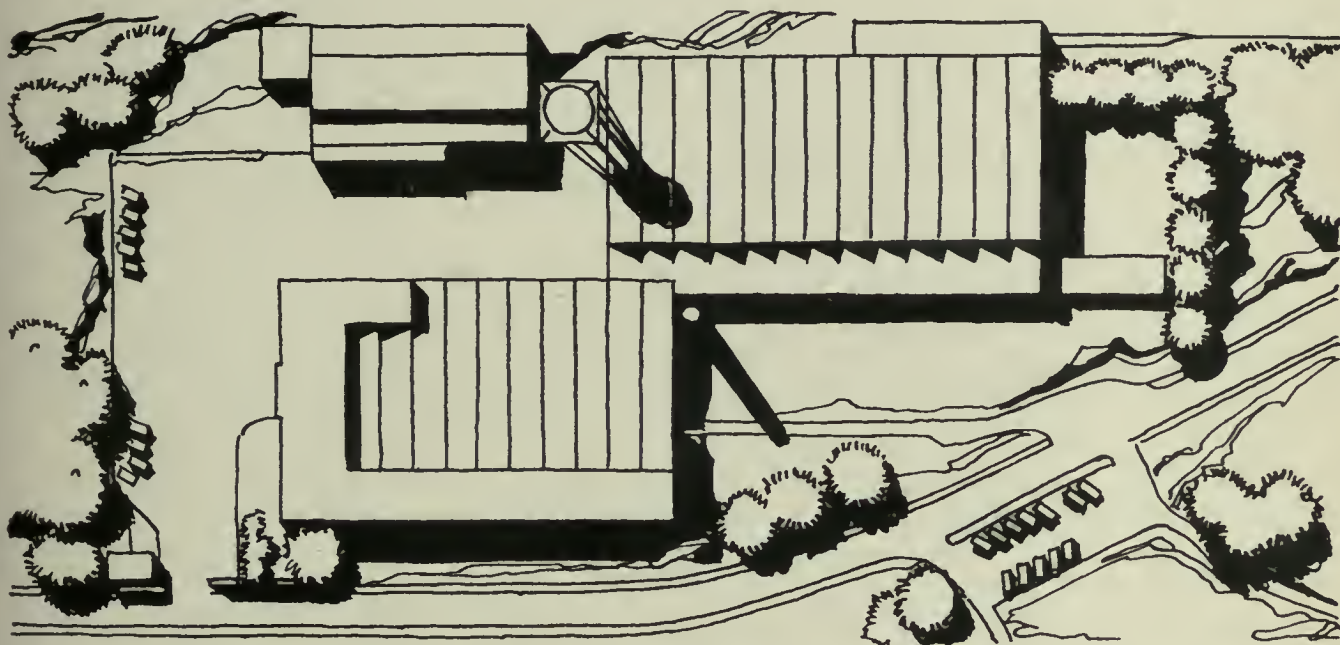
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TYPICAL REPORT FOR CAMOUFLAGING A FACTORY

1



Vertical view of a factory, 72,000 sq. ft. in size, in rural country. The site, along the highway, was leveled and cleared of trees. White pavements make the location very obvious in an aerial view.



The camouflage scheme reproduces the rural pattern, covering the factory, but leaving the highway exposed. Various groups of trees in adjacent plots invite the introduction of a meadow-and-tree pattern, built up in layers of overlapping flat-tops. Opaqueness of the screening and shape of the nets vary.

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TYPICAL REPORT FOR CAMOUFLAGING A FACTORY

2

I- Dangerous visibility and dangerous reflections: White spots lacking vegetation are very marked around factory, especially near railroad tracks, indicating heavy driving. Driveway, pavement, and turn-around near factory are too white. Parapet and limestone trim on office building, also triangular walls of sawtooth roof are obvious. Reflections come from sawtooth roof, water tower, and parked cars.

II- Dangerous vulnerability: Construction of factory is sound and modern. Damage through debris is not expected. Roof is not built to resist impact of bomb; explosion would occur inside plant, damaging all windows and disrupting transmissions. Water tower is exposed and water reserve insufficient without second source of supply.

III- Merits: Factory is simple in layout, without inaccessible courts. Factory is low, consisting only of one-story or low two-story buildings. Terrain is not flat, but has irregular grading with trees fairly near and on both sides of highway. Level of factory site is lower than adjacent terrain.

IV- Suggestions: White lines on the ground, curbs, water tower, fences, railings, white walls, small shacks should be painted dark as immediate precaution. Landmarks at some distance should be checked from airplane. Driveways and pavements not covered by camouflage construction should be darkened with dark coatings, renewed from time to time.

V- Program to reduce vulnerability: Additional supply of water should be provided, fire hydrants placed outside plant, to facilitate fire fighting. Water tower switch boards and valves should be provided with protective shelter, utilities should be subdivided or duplicated. Two protected observation posts should be installed at opposite sides of roof. Provisions should be made for individual protection of machinery and tools.

VI- Program for landscaping: Regularity of rows of trees should be broken. All white spots on ground or tracks covered with turf. Trees should be planted to protect parking fields. Pavements should be reduced to the minimum and shrubs or trees planted, conforming to adjacent landscape pattern.

VII- Program for camouflage: Covering the factory with nets is suggested as the cheapest method, quickest to install, without using too much metal. Reinforcing supporting members is not necessary as load is small. Camouflage has to include the railroad tracks and should be faded out under existing trees.

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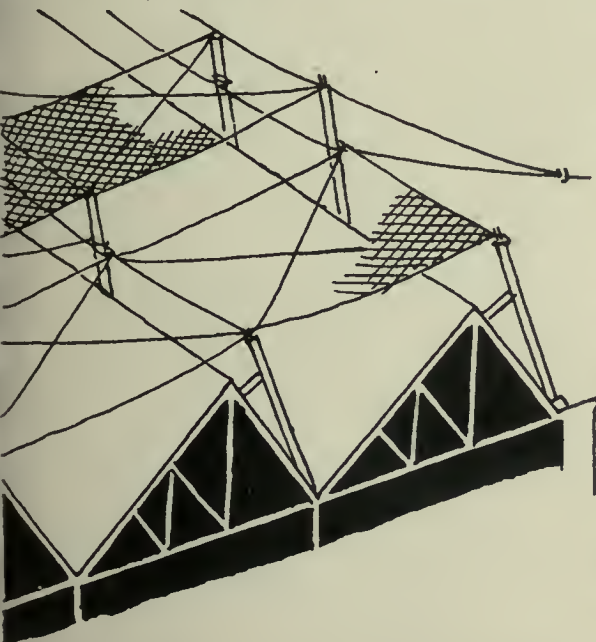
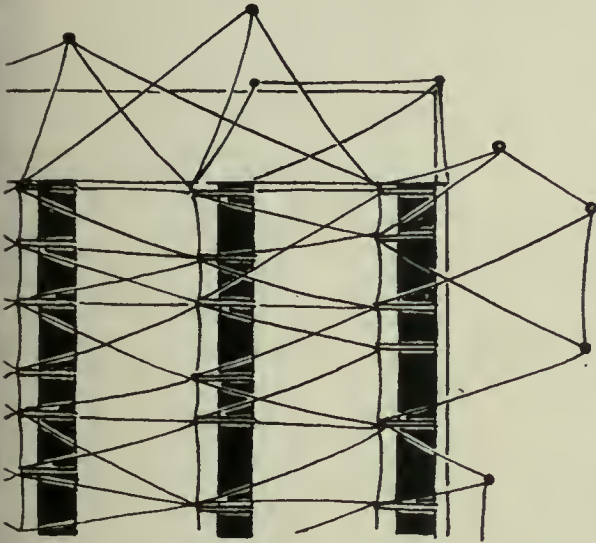
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TYPICAL REPORT FOR CAMOUFLAGING A FACTORY

3

CONSTRUCTION OUTLINE

Prepared by William J. McGuinness
A.S.C.E.



General Plan of Structure

The general arrangement of screening consists of flat surfaces of garlanded chicken-wire on three different levels, two of them above the factory, and one at a level below the factory roof and extending out on all sides. The main factory cover is intended to simulate the surrounding terrain. The upper layer, representing trees and some imitation of shrubs, covers up about one third of the factory. The lowest level conforms to the surrounding terrain.

Flat Surfaces

Chicken-wire, 20 gauge and 2" mesh is tied with $2\frac{1}{2}$ " garlands, properly painted and woven into the wire. The chicken-wire is kept flat by the use of 4-gauge wire, soft iron, forming panels about 10' x 30' over the factory in both layers. The spacing of supports is irregular to prevent detection by uniformity. In areas outside of the factory where the wire is supported on poles 30' and 50' high, the wire level is about 10' to 15' below the tops of poles. A suspension arrangement of wire is suggested, forming panels 20' x 60', which, in turn, would be divided into smaller panels supported by taut 4-gauge wire.

Vertical Supports

Each vertical support, if placed one over each column, in the typical 20' by 30' bays of the factory would bring in a load of 600 lbs. The column already takes a load of 123,000 lbs., so the added load would be less than 1% and perfectly safe. This is based upon an assumed sq. ft. load of 1 lb. for the garlanded chickenwire. The supports for the lower layer over the factory roof are 4' x 6's, for the two-layer part 4' x 10's, bolted through to the structural frame of the sawtooth truss. These have been figured for bending moment. The bolts should provide a great measure of steadiness to the installation. They may, however, have to be cross-braced with wire. No trouble is anticipated from wind pressure. It will be necessary to flash carefully where the bolts pass through the roof. The foot of supports may have to pass through the roof, and will have to be flashed, although it may be possible to rest them directly on a wood pad set in mastic and wedges provided below to bring the post to bearing.

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TYPICAL REPORT FOR CAMOUFLAGING A FACTORY

4

Accessibility

The reason for having the layer at least 5 feet above the roof is that incendiaries landing on the roof can be spotted and dealt with; also it makes possible greater access in the erection of the garlanded wire. A third advantage is that colored cloth can be rolled out under the garlands in case it becomes necessary to change or modify the color presented to aerial observation.

Low Level Outside of Factory Limits

The lower level of wire above the factory must be extended out on all sides for a distance of 20' for obscurement. Also it is necessary to create a new level around the factory, extending out 20' to 80' to aid in breaking up shadow from the upper one, as well as to cover loading and parking. Free movement must be possible in this area, and so it is proposed to support this level on poles of the type used for telegraph or clothes lines. Such poles are obtainable in lengths of 55' and 35' which are the two sizes needed. It is common to sink them in the ground 5'. Frequently it is not necessary to guy them but it is recommended that wire be strung down to a concrete footing in each case. Note that the 50' posts support layers of camouflage at heights of 20' and about 40' above the ground, and the 30' posts support a layer at 20' above the ground. They will therefore project through the wire screening and must be garnished above, to simulate trees. The extra height, however, permits a suspension arrangement which makes it possible to space them in bays of 20' to 60', but irregularly.

Cost

The cost estimate accompanying this report is based very largely upon actual quotations and upon firm bids for some of the work. Current prices are used. With rapidly changing construction costs and the great variation in bids on this unusual work, it is likely that the estimate will indicate only the approximate cost.

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TYPICAL REPORT FOR CAMOUFLAGING A FACTORY

5

ESTIMATE OF COST

Description	Quantity	Labor	Material	Sub-contract	Total
Excavation	20 c.y.	\$40	-	-	\$40
Pole Contract	51 poles	-	-	\$1910	1910
Timber Uprights	8200 bd. ft.	246	\$410	-	656
Bolts	288	-	50	-	50
Staples	4 kegs	-	16	-	16
#4 Wire	18000 ft.	150	107	-	257
$\frac{1}{4}$ " Cable	2000 ft.	50	75	-	125
Concrete	20 c.y.	40	120	-	160
#16 Wire	100 rolls	-	50	-	50
Cut Roof	-	144	-	-	144
Flash Roof	-	144	75	-	219
Chicken-wire	116200 s.f.	700	1390	-	2090
Apply Painted Garlands	900000 l.f.	500	3190	-	3650
Spray Garlands	-	500	100	-	600
Freight	-	-	35	-	35
Scaffold	-	100	50	-	150
Tools and Equipment	-	20	100	-	120
Supervision	3 wks.	225	-	-	225
Painting Tower and Light Surfaces	-	200	70	-	270
Darkening Road	-	400	100	-	500
Turf on Light Ground	-	-	-	300	300
Fake Trees	-	200	80	-	280
Darken Neighbor's Road	-	180	90	-	270
Subtotals		\$3839	\$6068	\$2210	\$12117

Liability and Compensation Insurance (15% of payroll)	576
Overhead 8%	969
Profit 10% (on cost - excluding insurance)	1308

Total \$14970

Probable replacement cost of factory building (1,800,000 c.f. at 40¢)	\$720,000
Net building area	72,000 sq. ft.
Net camouflage area	115,000 sq. ft.
Cost of camouflage installation per sq. ft. of factory	20.8¢
Cost of camouflage installation per sq. ft. of camouflage area	13.0¢
Cost of camouflage installation as a percentage of factory building cost	2.08%

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IN CONCLUSION

A desire to share our experiences in this fascinating and important field of study has motivated our action. Should circumstances justify, we plan to present succeeding volumes, the next of which is already well under way.

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Thanks are due to the McLaughlin Air Service, Madison Avenue, New York, for permission to use the aerial photographs on pages 7, 8, 9, 10, 17, 34, 37, 48, 61, 70, 95, and 116. The drawing on page 18 is reproduced by courtesy of FORTUNE magazine; this drawing was prepared by K.F. Wittmann for an article on camouflage, March, 1942.

The diagrams on pages 27, 28, and 29 were first published in an article by K.F. Wittmann on "Bird's-eye Planning" in the September, 1940, ARCHITECTURAL RECORD.

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