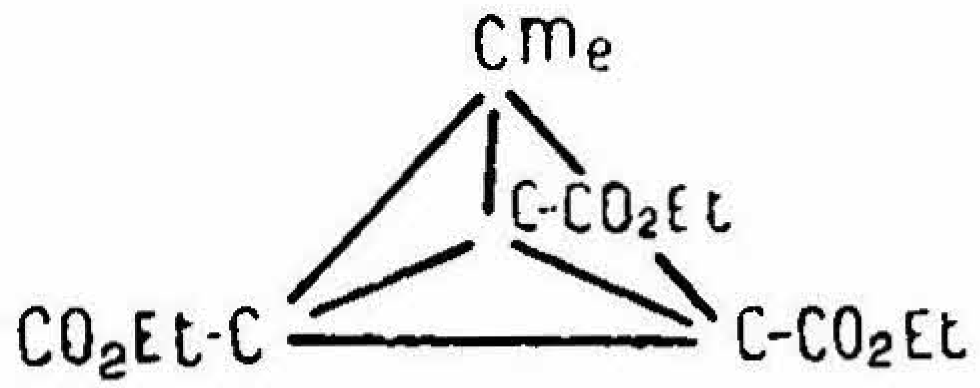
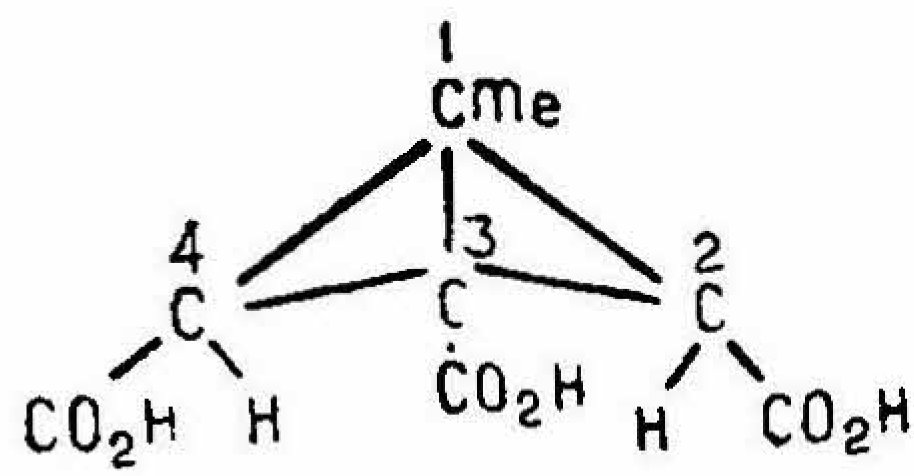
II. POLYCYCLIC AND CAGE SYSTEMS OF CARBON COMPOUNDS.

By J. J. Sudborough and P. Ramaswami Ayyar.

The chain of carbon atoms of a normal paraffin hydrocarbon is not straight, but at each carbon atom the line is bent so that compounds containing 5 or 6 carbon atoms readily form closed rings belonging to the isocyclic division of carbon compounds. Similarly, two polymethylene rings when condensed do not lie in the same plane, but form an angle with each other, and when sufficient cycloparaffin rings are present they give rise to a closed system of rings, termed by Beesley and Thorpe[1] 'a cage.' In addition to such closed cages, other spatial arrangements occur, e.g., the compound $C_{20}H_{28}$ mentioned on p. 178. Probably the first representation of an isocyclic cage system was Ladenburg's prism formula for benzene, but the first compound to which a cage structure was definitely assigned is the substance represented by formula I and first prepared by Beesley and Thorpe. This triethyl ester was obtained by brominating the tribasic bicyclic acid, II, 1B-1:3, 1-methyl-*cyclo*butane-2:3:4-tricarboxylic acid, and pouring the product into alcohol.



I.

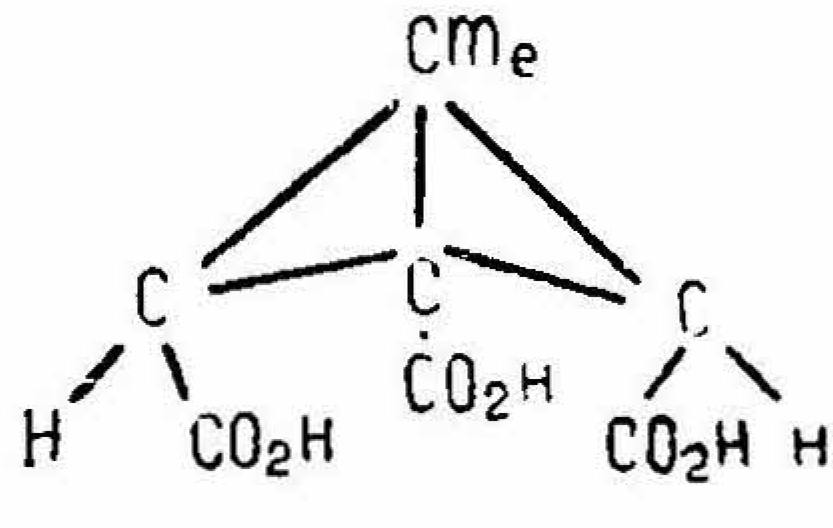


II.

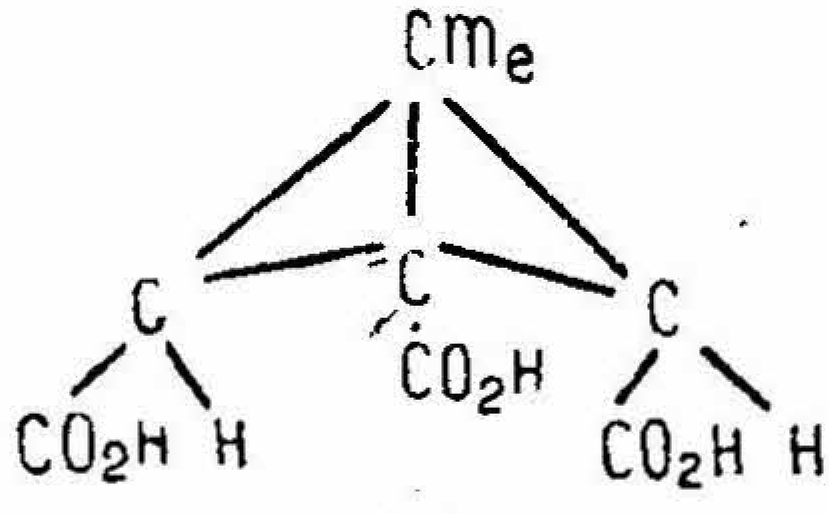
The reaction consists in replacing the hydrogen atom attached to carbon atom No. 2 by bromine, the removal of the bromine attached to this atom with the hydrogen atom No. 4 and the formation of a new *cyclo*propane ring. At the same time the carboxylic groups are converted into COBr groups and finally, under the influence of the alcohol, into ·CO·OEt groups.

The acids III and IV which are stereoisomeric with No. II, and which differ only in the spatial arrangement of the hydrogen atoms and carboxyl groups attached to carbon atoms numbered 2 and 4, do not yield a cage system under similar treatment.

[1] *J. Chem. Soc.*, 1920, 117, 617.



III.



IV.

The cause of the ready removal of hydrogen bromide and the closing of the ring is to be sought in the *cis*-positions of the hydrogen atoms in the acid II, i.e., in the *cis*-positions of the hydrogen and bromine after bromination.

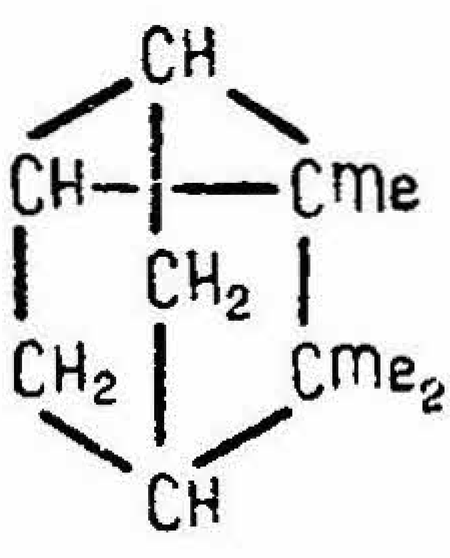
Other compounds with cage structures had been previously prepared, although their cage structure had not been indicated at the time. Among these are the tricyclic compounds represented by formulae V to VIII :—

V. Semmler's tricyclene,[1] 2B-1:3, methene-2:7:5,-3:4:4-trimethyl-*cyclo*hexane, from pinene dibromide, zinc dust and alcohol.

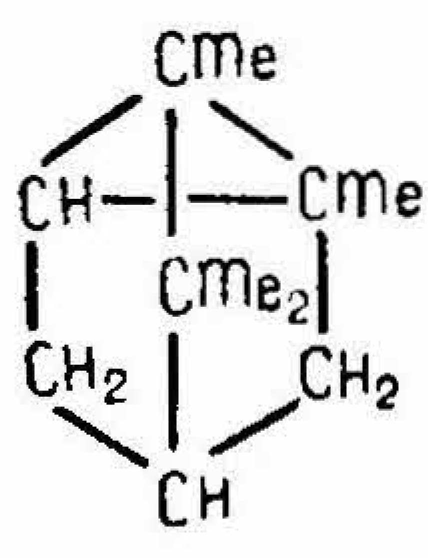
VI. Bredt and Savelsberg's[2] 'Homocyclene,' 2B-1:3, dimethyl-methene-2:7:5,-2:3-dimethyl-*cyclo*hexane, from camphor and fenchone by the aid of magnesium methyl iodide.

VII. Wagner and Brykner's *iso*cyclene,[3] 2B-1:3, methene-2:7:5, 4:4:5-trimethyl-*cyclo*hexane.

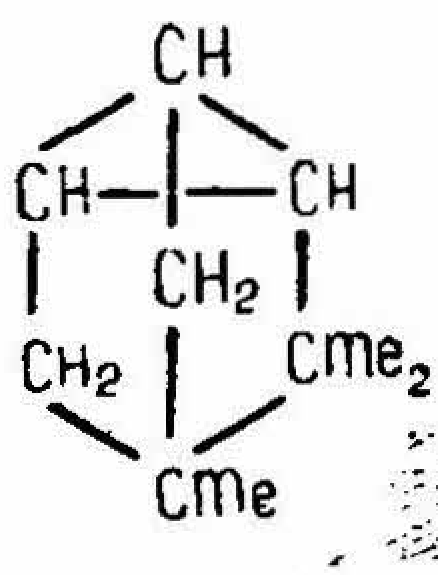
VIII. Teresantalic acid.[4]



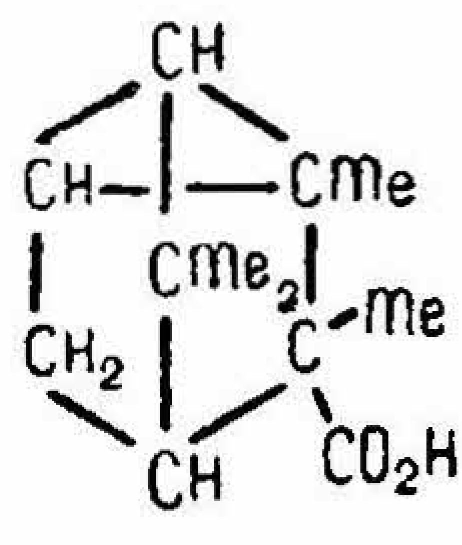
V.



VI.



VII.



VIII.

If it is assumed that all carbon atoms directly united are the same distance apart as stated by Ingold,[5] then the compounds formed by bridging the *cyclo*-hexane ring as in formulae V to VIII will possess a cage type of structure.

[1] *Ber.*, 1902, 35, 1018.
[2] *J. Pr. Chem.*, 1918, [ii], 98, 99.
[3] *J. Russ. Phys. Chem. Soc.*, 1903, 35, 536.
[4] Semmler, *Ber*, 1911, 44, 463.
[5] *J. Chem. Soc.*, 1920, 117, 607.

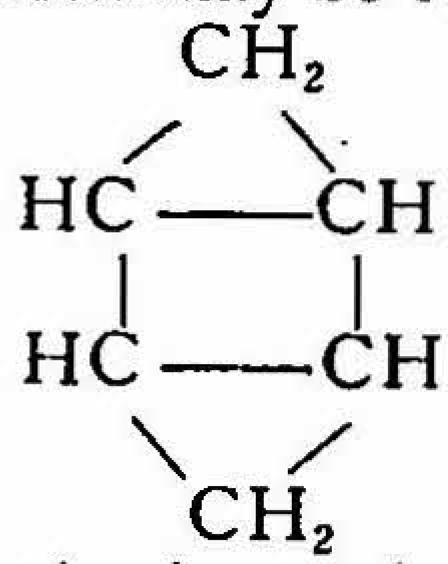
When a simple *cyclo*-paraffin ring is bridged the whole of the carbon atoms constituting the original ring no longer lie in a single plane, i.e., the two smaller rings obtained by bridging the original large ring are not co-planar but form an angle with one another.

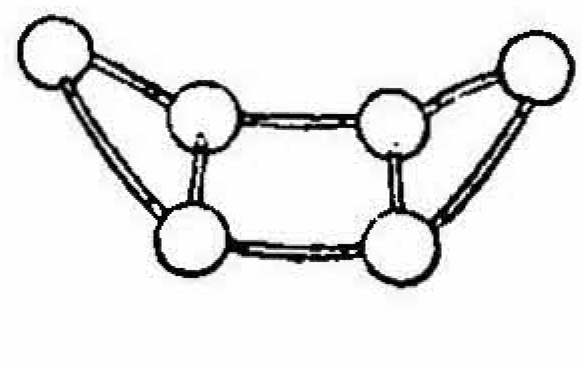
Practically all the systems dealt with in this paper are saturated cyclic, or rather polycyclic, systems and are derived from the *cyclo*-paraffins. In any particular *cyclo*-paraffin the hydrogen atoms do not all lie in one plane, but are symmetrically arranged in two planes one above the plane in which the carbon atoms constituting the ring are placed and the other below this. This arrangement gives rise to stereo-isomerism in the case of a disubstituted derivative, e.g., the well known *cis*-and *trans*-stereoisomerism of the *cyclo*-hexanedicarboxylic acids. The existence of the two planes of hydrogen atoms complicates the formation of bridges in cyclic paraffins. Thus in the case of a single bridge, whether a plain diagonal linkage or a bridging by means of one or two methene groups, the one hydrogen atom replaced may be in the *cis*-plane and the other in the *trans*-plane. Models show that a *cis-cis*-bridge, whether simple or containing several atoms, usually entails less strain in the molecule, and in the subsequent discussion it will be assumed that each individual bridge is a *cis-cis*-or *trans-trans*-bridge and not a *cis-trans*. In other words, the two hydrogen atoms in the ring replaced by the bridge always lie on the same side of the molecule.

When two bridges are present, then both bridges may be *cis* or one may be *cis* and the other *trans*, i.e., all four hydrogen atoms replaced may lie in the same plane or the two replaced by the one bridge may lie in a different plane from the two replaced by the second bridge.

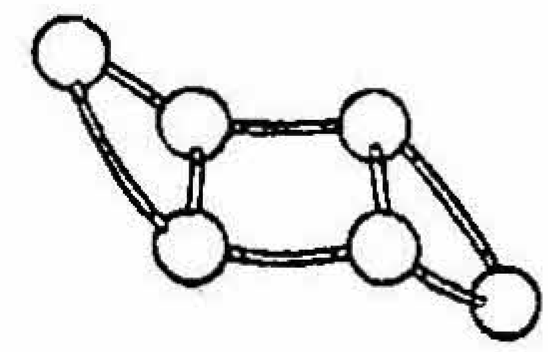
It follows therefore that a compound such as that represented in Figure IX, which may be regarded as a derivative of *cyclo*hexane with two meta bridges, can exist in two forms depending on whether the two bridges are *cis* or *trans* with respect to one another. Each form will consist of one four-membered and two three-membered rings, but in (*a*) where the two linkings are *cis* the carbon atoms forming the apices of the two tri-rings lie on the same side of the plane of the tetra-ring and in (*b*) where the bridges are *trans* to one another the two apices lie on different sides of the tetra-ring.

IX.





a).



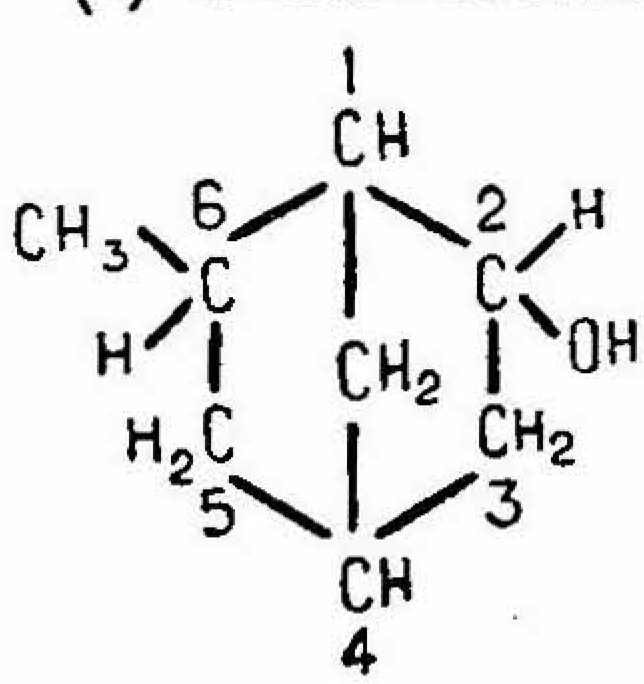
b).

In certain cases both forms, i.e., the doubly bridged *cis*-and the doubly bridged *trans*-form, appear to give equally stable systems and hence the number of possible compounds is increased. In other cases, e.g., two meta-and one para-bridge, the one form appears to be more stable than the others, as indicated by the strain entailed in forming models. In these cases only the more stable form is considered.

The difficulties engendered by the *cis*-and *trans*-arrangements of the hydrogen atoms when attempts are made to bridge a cyclic or polycyclic paraffin are well illustrated by the following examples.

(*a*) In attempting to form a 1:4-methene bridge in the compound, $$CH_3\text{-}\underset{1}{CH}\left\langle\begin{matrix}CH_2\text{-}CH_2\\ CH_2\text{-}CH_2\end{matrix}\right\rangle\underset{4}{CH}\text{-}CH_2\text{-}OH,$$ by the elimination of water, it is clear from what has been already stated that to obtain the bridging the H attached to carbon atom No. 1 and the CH_2-OH group attached to carbon atom No. 4 must be *cis* with respect to each other. If they are *trans* then bridging will not take place.

(*b*) Somewhat more complex is the case represented by formula X where it is desired to form a plain meta-bridge by the elimination of water. Not only is it necessary that the OH attached to carbon atom No. 2 shall be in the *cis*-position with respect to the hydrogen atom attached to carbon atom No. 6, but it is also necessary that both this OH and H shall be *trans* with respect to the para bridge already present.[1]

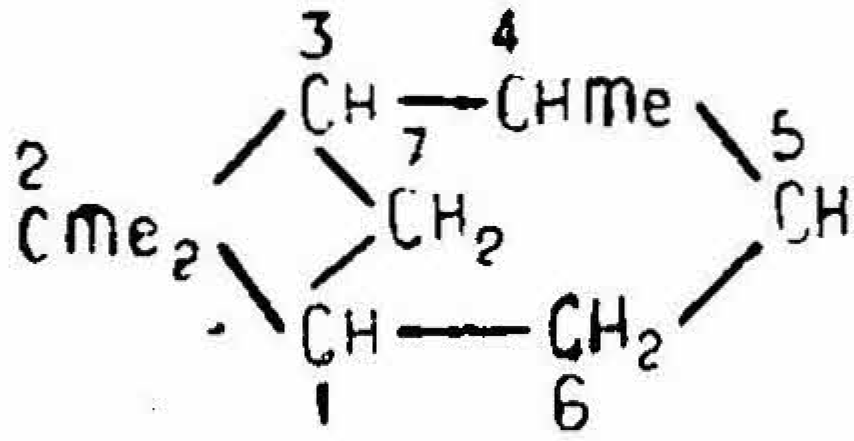


X.

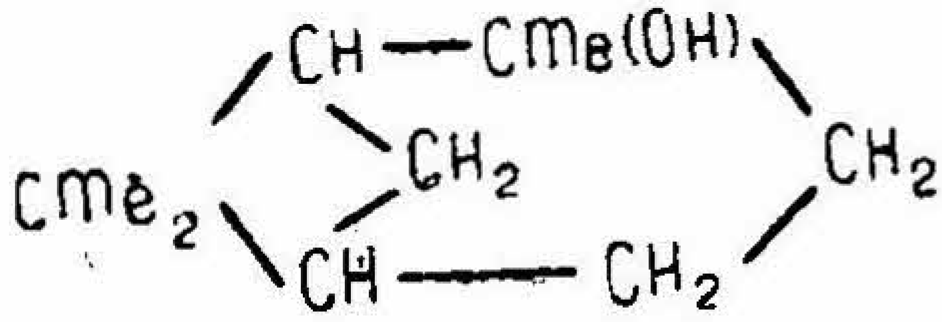
It is obvious that in most of these polycyclic compounds *cis-trans*-isomerism analogous to that occurring in the simple *cyclo*paraffins will prevail when two substituents attached to two different methene groups are present.

[1] Another example of this type is seen in the elimination of hydrogen bromide from one only of the three stereoisomeric acids mentioned by Beesley and Thorpe, *loc. cit.*

Another interesting type of *cis-trans*-isomerism is met with when there is a bridge present and also a single substituent, e.g., methyl in one of the methene groups. Then the bridge may be either *cis* or *trans* to the methyl group. An example of such isomerism is to be found in the literature, viz., 1B-methene-1:7:3,-2:2:4-trimethyl-*cyclo*hexane,[1] XI.



XI.



XII.

Two isomeric compounds have been isolated and the isomerism is undoubtedly due to the relative positions of the methene bridge and the methyl group in the 4-position. An analogous example is the corresponding 4-ol,[2] XII.

The following pages give a classified list of a number of relatively simple isocyclic cage systems and closely related systems. In a number of cases their relationship to tetra-, penta-, and hexa-methylene rings is indicated, e.g., the number and arrangement of the bridges.

The molecular formula is given in each case, also the number and types of unbridged rings forming the cage and finally the systematic name for each compound based on the principles detailed in Part I.

In the description of the types of rings constituting the cage or complex system it should be clearly understood that the carbon atoms constituting a ring do not necessarily all lie in the same plane, as they presumably do in the molecule of a simple *cyclo*paraffin, and hence the stabilities of many of these rings cannot be compared with those of the corresponding *cyclo*paraffins.

On plates IV-IX plane formulae for most of the compounds are given and these illustrate the system of numbering. On plates X and XI representations of the spatial models of some of the more interesting compounds are given.

[1] Nametkin, *J. Russ. Phys. Chem. Soc.*, 1922, 54, 177.
[2] Lipp, *Ber.*, 1923, 56B, 2101.

CLASSIFICATION OF

A. *Simple*

No.	Base	Formula
1	Three-carbon ring. Single pyramid	C_4H_4
2[1]	Three-carbon ring. Double pyramid	C_5H_2
3[1]	Four-carbon ring. Single pyramid	C_5H_4
4[1]	Four-carbon ring. Double pyramid	C_6

B. *Simple*

No.	Base	Formula
1	Three-carbon ring. Two such rings parallel and joined by three pairs of carbon atoms	C_6H_6
2	Four-carbon ring. Two parallel and joined by four pairs of carbon atoms.	C_8H_8
3	Four-carbon ring. Two parallel and joined by three pairs of carbon atoms.	C_8H_{10}
4	Four-carbon ring. Two parallel and joined by two symmetrical pairs of carbon atoms.	C_8H_{12}
5	Two five-rings parallel and joined by five pairs of carbon atoms.	$C_{10}H_{10}$
6	Two six-rings parallel and joined by six pairs of carbon atoms.	$C_{12}H_{12}$
7	Two six-rings parallel and joined by three alternate pairs of carbon atoms.	$C_{12}H_{18}$
8	Two six-rings parallel and joined at para-para positions ...	$C_{12}H_{20}$
9	Same as B 8 but with phenyl in place of *cyclo*hexyl ...	$C_{12}H_8$
10	Three three-rings parallel and joined by six pairs of carbon atoms.	C_9H_6
11	Three four-C-rings parallel and joined by eight pairs of carbon atoms.	$C_{12}H_6$
12	Three six-C-rings parallel and joined by twelve pairs of carbon atoms.	$C_{18}H_{12}$
13	Similar to 12 but joined by six alternate pairs of carbon atoms.	$C_{18}H_2$
14	Two eight-carbon-rings parallel and joined at four points ...	$C_{16}H_{24}$

[1] Nos. A 2, A 3 and A 4 are highly improbable forms, as indicated by the strain entailed

[2] Similar to Ladenburg's prism formula for benzene.

Cage Systems.

pyramidal forms.

System of rings constituting cage	Systematic name
Four three-carbon rings	2B-1:3, 2:4,-*cyclo*butane.
Six three-carbon rings	4B-1:3, 1:4, 2:4, 2:5,-*cyclo*pentane.
Four three-carbon rings and one four-carbon-ring.	3B-1:3, 1:4, 2:5,-*cyclo*pentane.
Eight three-carbon rings	6B-1:4, 1:5, 2:4, 2:6, 3:5, 3:6-*cyclo*hexane.

prismatic forms

System of rings constituting cage	Systematic name
Two three-C-rings and three four-C-rings[2]...	3B-1:4, 2:6, 3:5-*cyclo*hexane.
A cube of six four-C-rings.	4B-1:6, 2:5, 3:8, 4:7,-*cyclo*octane.
Four four-C-rings and one six-C-ring ...	3B-1:4, 2:7, 3:6,-*cyclo*octane.
Two four-C-rings and two six-C-rings ...	2B-methene-1:7:5, 2:8:4,-*cyclo*hexane.
Five four-C-rings at sides, top and bottom of two five-C-rings.	5B-1:7, 2:6, 3:10, 4:9, 5:8,-*cyclo*decane.
Sides of six four-C-rings, top and bottom two six-C-rings.	6B-1:8, 2:7, 3:12, 4:11, 5:10, 6:9,-*cyclo*dodecane.
Sides of three six-C-rings, top and bottom two six-C-rings.	3B-4:9, methene-1:11:7, 2:12:6,-*cyclo*decane.
Sides of two eight-C-rings, top and bottom of two six-C-rings.	2B-dimethene-1:9:10:6, 2:11:12:5,-*cyclo*octane.
Ibid	2B-dimethine-1:9:9:10:6, 2:11:11:12:5,-*cyclo*-octa-$\Delta^{2:4:6:8}$-tetrene.
Sides of six four-C-rings ; top and bottom of two three-C-rings.	6B-1:8, 2:5, 2:7, 3:7, 3:9, 4:6,-*cyclo*nonane.
Sides of eight four-C-rings and top and bottom of two four-C-rings.	8B-1:10, 2:7, 2:9, 3:6, 3:12, 4:9, 4:11, 5:8,-*cyclo*-dodecane.
Side of twelve four-C-rings and top and bottom of two six-C-rings.	12B-1:14, 2:11, 2:13, 3:10, 3:18, 4:9, 4:17, 5:8, 5:16, 6:13, 6:15, 7:12,-*cyclo*octadecane.
Sides of six-C-rings ; top and bottom of two six-C-rings.	6B-2:11, 3:8, 4:15, 5:12, methene-1:17:13, 6:18:10,-*cyclo*hexadecane.
Top and bottom of two eight-C-rings and sides of four six-C-rings.	4B-4:13, 6:11, methene 1:15:9, 2:16:8,-*cyclo*-tetradecane.

in making such cages with the aid of Engler's atom models.

CLASSIFICATION OF

C. *Two parallel rings joined by*

No.	Base	Formula
1	Two four-C-rings parallel and joined at two opposite corners by methene bridges.	$C_{10}H_{16}$
2	Two four-C-rings joined directly at two opposite corners and by two methene bridges at remaining two.	$C_{10}H_{12}$
3	Two four-C-rings parallel and joined by methene bridges at each corner.	$C_{12}H_{16}$
4	Two six-C-rings parallel and joined by three methene bridges at three symmetrical positions.	$C_{15}H_{24}$
5	Two six-C-rings parallel, joined directly at three alternate points and at remaining points by three methene groups.	$C_{15}H_{18}$
6	Two six-C-rings parallel and joined at alternate points with three dimethene bridges.	$C_{18}H_{30}$
7	Two six-C-rings parallel and joined at four symmetrical points by methene bridges.	$C_{16}H_{24}$

D. *Bridged hexamethylene and*

1	*Cyclo*hexane with two para bridges (*trans.*)	C_6H_8
2	*Cyclo*hexane with two para methene bridges (*trans.*) ...	C_8H_{12}
3	*Cyclo*hexane with two meta bridges (*a*) *cis*	C_6H_8
	Do. (*b*) *trans*	C_6H_8
4	*Cyclo*hexane with two meta methene bridges *cis* or *trans* ...	C_8H_{12}
5	*Cyclo*hexane with one meta and one para bridge (*trans.*) ...	C_6H_8
6	*Cyclo*hexane with one meta bridge and one para methene bridge (*trans.*)	C_7H_{10}
7	*Cyclo*hexane with one meta methene and one para methene bridge (*trans.*)	C_8H_{12}
8	*Cyclo*hexane with one para and one methene para bridge (*trans*).	C_7H_{10}
9	*Cyclo*hexane with two meta bridges and one para bridge: the para *trans* to the two meta bridges.	C_6H_6
10	*Cyclo*hexane with two meta bridges and one para methene bridge *trans* to the two meta bridges.	C_7H_8

[1] In numbering preference is

CAGE SYSTEMS.—(*contd.*)

methene or polymethene bridges.

System of rings constituting cage	Systematic name
Two sides of eight-C-rings: top and bottom of two four-C-rings.	2B-methene-1:9:7, 3:10:5,-*cyclo*octane.
Top and bottom of two four-C-rings: sides of four five-C-rings.	4B-1:7, 2:6, 3:9, 4:8,-*cyclo*decane.
Four sides of six-C-rings: top and bottom of two four-C-rings.	4B-1:8, 2:7, 4:11, 5:10,-*cyclo*dodecane.
Three sides of eight-C-rings: top and bottom of two six-C-rings.	3B-methene-1:13:7, 3:14:11, 5:15:9,-*cyclo*dodecane.
Sides of six five-C-rings: top and bottom of two six-C-rings.	6B-1:12, 2:6, 3:14, 4:8, 7:11, 9:13,-*cyclo*pentadecane.
Sides of three ten-C-rings: top and bottom of two six-C-rings.	3B-methene-3:17:13, 6:18:10, dimethene-1:15:16:8,-*cyclo*tetradecane.
Top and bottom of two eight-C-rings and sides of four six-C-rings. Identical with B 14.	....

reduced napthalene rings.

System of rings constituting cage	Systematic name
System of four four-C-rings	2B-1:4, 2:5,-*cyclo*hexane.
System of four five-C-rings	2B-1:5, 3:7,-*cyclo*octane.
One four-C-ring and base and two three-C-rings on same side	2B-1:5, 2:4,-*cyclo*hexane.
Do. do. do. on opposite sides.	
Base of one six-C-ring and ends of two four-C-atoms. Identical with B4.	2B-methene-1:7:5, 2:8:4,-*cyclo*hexane.
Base of one three-C-ring sides of two four-C-and one five-C-rings.	2B-1:3, 2:5,-*cyclo*hexane.
Base of one three-C-ring, sides of three five-C-rings.	2B-1:3, methene-2:7:5,-*cyclo*hexane.
Base of one six-C-ring, sides of one four-C-and two five-C-rings.	2B-1:4, methene-2:8:6,-*cyclo*heptane.[1]
Base of one four-C-ring, sides of one four-C-and two five-C-rings.	2B-1:4, 2:6,-*cyclo*heptane.
Identical with B 1	....
Base of one four-C-rings, sides of two five-C-rings and ends of two three-C-rings.	3B-1:4, 2:7, 3:5,-*cyclo*heptane.

given to the shorter bridge: *cf.* p. 160.

D. *Bridged hexamethylene and*

No.	Base	Formula
11	*Cyclo*hexane with one para-bridge and two meta-methene bridge, *cis* to one another but *trans* to the para-bridge.	C_8H_{10}
12	*Cyclo*hexane with two meta-methene bridges (*cis*) and one para-methene bridge *trans*.	C_9H_{12}
13	*Cyclo*hexane with one para-bridge and two ortho-methene bridges. (*a*) All *cis* (*b*) ortho *cis*, and para *trans*, (*c*) one ortho and para *cis* and second ortho *trans*.	C_8H_{10}
14	*Cyclo*hexane with one dimethine bridge, each CH attached symmetrically to two ortho-C-atoms of the original ring.	C_8H_{10}
15	One dimethine bridge as in D 14 but with an additional para-linking (*trans*.)	C_8H_8
16	*Cyclo*hexane with one dimethine bridge each CH. attached to two meta-C-atoms of ring.	C_9H_{10}
17	*Cyclo*hexane with one dimethine bridge as in D 16 and with a para-linking *trans* to the dimethine.	C_8H_8
18	*Cyclo*hexane with one dimethine bridge as in D 16 and a *trans* para-methene bridge.	C_9H_{10}
19	*Cyclo*hexane with two meta-dimethene bridges (*cis*) and one para-methene bridge (*trans*.)	$C_{11}H_{16}$
20	*Cyclo*hexane with two ortho-dimethene bridges *cis* and one plain para bridge *trans*.	$C_{10}H_{14}$
21	*Cyclo*hexane with two ortho-dimethene bridges *cis* and one para-methene bridge *trans*.	$C_{11}H_{16}$
22	*Cyclo*hexane with two ortho-dimethene bridges *cis* and one para-dimethene bridge *trans*.	$C_{12}H_{18}$
23	*Cyclo*hexane with two meta-dimethene bridges *cis* and one para-dimethene bridge *trans*	$C_{12}H_{18}$
24	*Cyclo*hexane with a *cyclo*butane bridge, the four carbons of latter joined to carbons 1:2:4:5 of former.	$C_{10}H_{12}$
25	Same as D 24 but joined to carbons 1:2:3:4. ...	$C_{10}H_{12}$
26	Decahydronapthalene with plain para-linking in each ring (*cis*).	$C_{10}H_{14}$
27	Same as D 26 but meta-linking (*cis*) in each ring in place of para.	$C_{10}H_{14}$

CAGE SYSTEM—*(contd.)*

reduced naphthalene rings—(contd.)

System of rings constituting cage	Systematic name
Practically identical with B 3	......
Base of one six-C-ring, sides of two five-C-ring and ends of two four-C-rings. [1]	3B·1:5, 2:8, 4:7,-*cyclo*nonane.
One three-C-ring, two four-C-rings, one three-C-ring.	3B·1:7, 2:6, 3:5,-*cyclo*octane.
Base of one six-C-ring, sides of two five-C-rings and ends of two three-C-rings.	3B·1:5, 2:8, 4:6,-*cyclo*octane.
Bottom of two four-C-rings, ends of two three-C-rings and sides of two five-C-rings.	4B·1:5, 2:8, 3:7, 4:6,-*cyclo*octane.
Base of one six-C-ring and sides of four four-C-rings. Practically identical with B3.	3B·1:4, 2:7, 3:6,-*cyclo*octane.
Cube. Identical with B2	......
Base of two four-C-rings, ends of two four-C-rings and sides of two five-C-rings.	4B·1:6, 2:5, 3:9, 4:7,-*cyclo*nonane.
Base of one eight-C-ring, ends and sides of four five-C-rings.	3B·1:5, 2:9, 4:8,-*cyclo*undecane.
Four four-C-rings [2]	3B·1:8, 2:7, 3:6,-*cyclo*decane.
Two four-C-rings and two five-C-rings ...	3B·1:8, 3:6, methene-2:11:7,-*cyclo*decane.
Two four-C-rings and two six-C-rings ...	3B·1:8, 3:6, dimethene-2:11:12:7,-*cyclo*decane.
Base of one eight-C-ring, sides of two six-C-rings and ends of two five-C-rings.	3B·1:6, 2:10, 5:9,-*cyclo*dodecane.
Base of one six-C-ring, top and sides of three four-C-rings and ends of two five-C-rings.	4B·1:6, 2:5, 3:9, 4:8,-*cyclo*decane.
Base of one six-C-ring, sides and ends of three four-C-rings and one six-C-ring, top of one four-C-ring.	4B·1:6, 2:5, 3:8, 4:7,-*cyclo*decane.
Sytem of four four-C-rings same as D 20 ...	......
System of two three-C-rings and two five-C-rings.	3B·1:9, 2:7, 3:5,-*cyclo*decane.

[1] This is the same figure as C2 less one CH_2 group.
[2] This minus four hydrogen atoms gives B5.

CLASSIFICATION OF

D. *Bridged hexamethylene and*

No.	Base	Formula
28	Same as D 27 but carbon atoms common to two original *cyclo*-hexane rings involved.	$C_{10}H_{14}$
	Bridges between the two rings	
29	Decahydronaphthalene with bridges between carbon atoms 3 and 9 and 4 and 8 of original molecule.[1]	$C_{10}H_{14}$
30	Same as D 29 but with plain para-bridge in each ring ...	$C_{10}H_{10}$
31	Decahydronaphthalene with bridges between carbons Nos. 3 and 10, 4 and 7 of original rings.	$C_{10}H_{14}$
32	Decahydronaphthalene with bridges between carbons Nos. 2 and 10, 5 and 7 of original rings.	$C_{10}H_{14}$
33	Decahydronaphthalene with bridges between carbons Nos. 2 and 5, 3 and 9, 4 and 8 of original rings.	$C_{10}H_{12}$
34	Decahydronaphthalene with bridges between carbons Nos. 2 and 5, 3 and 10, and 4 and 7 of original rings.	

E. *Miscel*

No.	Base	Formula
1	D 18 with two more methene bridges; i.e., two six-C-rings parallel joined at 4 points, viz., 1, 2, 4, 5 of lower with 1, 3, 4, 6 of upper and upper ring with a para dimethene bridge.	$C_{14}H_{18}$
2	*Cyclo*hexane with a : CH·CH$_2$·CH : bridge attached to carbons Nos. 1, 2, 4 and 5.	C_9H_{12}
3	Same with an additional para methene bridge (*trans*) ...	$C_{10}H_{12}$
4	*Cyclo*hexane bridged at 6 points with a *cyclotet*radecane at carbons 1:3:5:8:10:12.[2]	$C_{20}H_{28}$
5	Two diphenyl groups attached in *pp*-positions	$C_{24}H_{18}$

[1] These figures refer to the numbers of the carbon atoms in the
[2] May be regarded as an acenaphthene type of compound derived

CAGE SYSTEMS—(*contd.*)

reduced naphthalene rings—(contd.)

System of rings constituting cage	Systematic name
Ibid	3B-1:9, 4:6, 4:9,-*cyclo*decane.
in the naphthalene molecule—	
Base of one four-C-ring sides of two six-C-rings and ends of two five-C-rings.	3B-1:7, 2:6, 4:9,-*cyclo*decane.
Same as B 5	......
Base of one six-C-ring, sides of two six-C-rings and ends of two four-C-rings.	3B-1:8, 2:5, 4:9,-*cyclo*decane
Base of one eight-C-ring, sides of two six-C-rings and ends of two three-C-rings.	3B-1:6, 2:10, 5:7,-*cyclo*decane.
Identical with D 24.	
Identical with D 25.	......

laneous.

Base of one six-C-ring, sides of four five-C-rings and top of two six-C-rings.	4B-1:9, 2:7, 3:12, methine-4:8:14:11,-*cyclo*tridecane.
Base of one six-C-ring, sides of two six-C-rings and ends of two-three C-rings.	3B-2:8, 4:6, methene-1:9:5,-*cyclo*octane.
Base of two five-C-rings, sides of two six-C-rings and ends of two three-C-rings.	4B-1:5, 2:10, 3:7, 6:8, *cyclo*decane.
System of four five-C-rings and three six-C-rings	6B-2:7, 3:17, 4:15, 5:13, 6:10, methene-1:20:8,-*cyclo*nonadecane.
......	4B-dimethine- 1:17:17:18:14, 2:19:19:20:5, 6:21:21:22:9, 10:23:23:24:13,-*cyclo*hexadeca-Δ 2:4:6:8:10:12:14:16-octene.

naphthalene ring starting with one of the quaternary carbons as No. 1.
from anthracene perhydride.

As already pointed out[1] Beesley and Thorpe have prepared derivatives of the type A1, and Semmler, Bredt and Savelsberg, Wagner and Brykners and others derivatives of type D6. Farmer[2] has attempted to prepare compounds belonging to type B1, and Turner[3] has failed in preparing derivatives of type B9.

In these laboratories experiments have been started with the object of preparing compounds belonging to the types B8, B14 and D10.

For the compound B8 the following series of reactions are being studied.

$$NH_2\cdot C_6H_4\text{-}C_6H_4\cdot NH_2 \longrightarrow OH\cdot C_6H_4\cdot C_6H_4\cdot OH \longrightarrow OH.C_6H_{10}\cdot C_6H_{10}\cdot OH$$

Benzidine.

$$\longrightarrow IC_6H_{10}\cdot C_6H_{10}I \longrightarrow C_6H_{10}\cdot C_6H_{10}$$

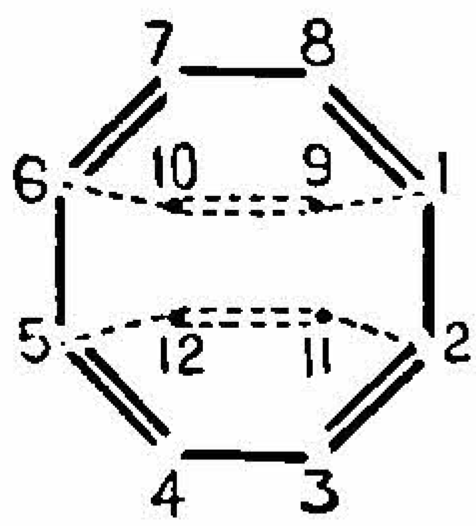
For a compound belonging to type B14, the reactions under examination are the elimination of hydrogen chloride from the acid chloride of anthraquinone-2:6-dicarboxylic acid or of water from the corresponding acid.

The method adopted for preparing a compound derived from the parent substance, type D10, is the elimination of water from the di-tertiary alcohol,[4] 1:2-dimethylcamphan-1:2-diol., obtained by condensing camphor-quinone with magnesium methyl iodide.

In conclusion we wish to thank Dr. H. E. Watson for many valuable suggestions.

[1] P. 166.
[2] *Ibid.*, 1923, **123**, 3332.
[3] *Ibid.*, 1915, **107**, 1495.
[4] Forster, *J. Chem. Soc.*, 1905, **87**, 141.

PLATE V.



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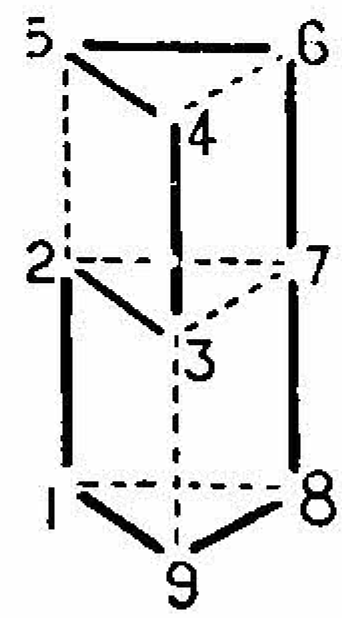

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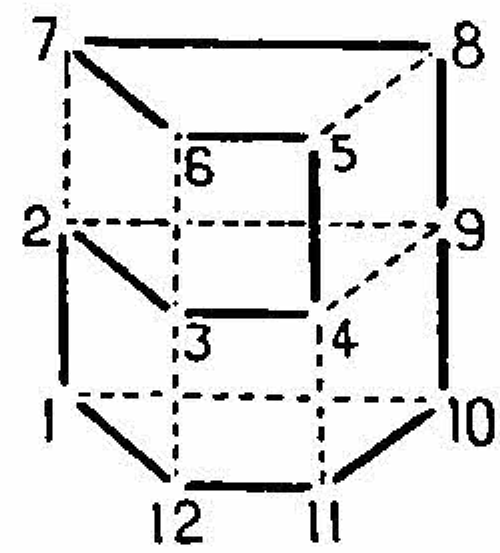

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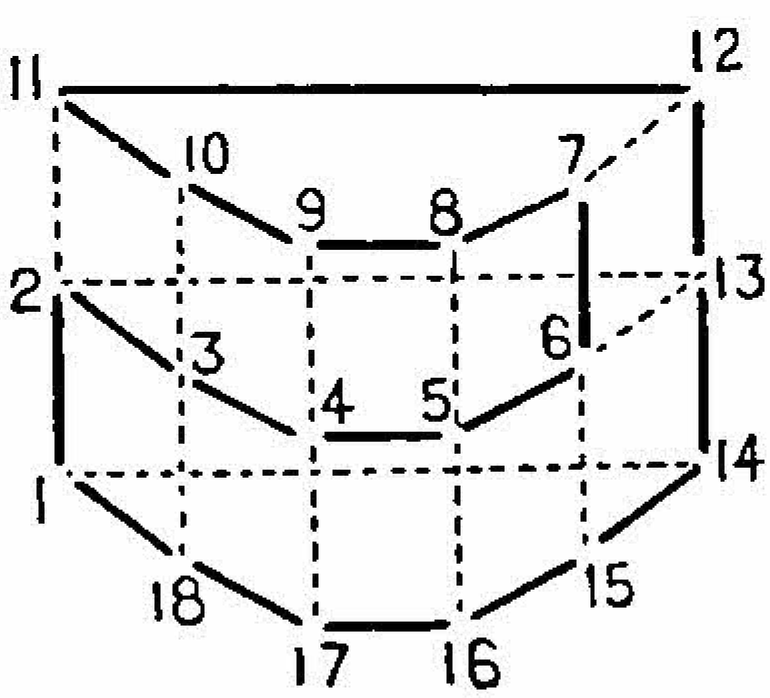

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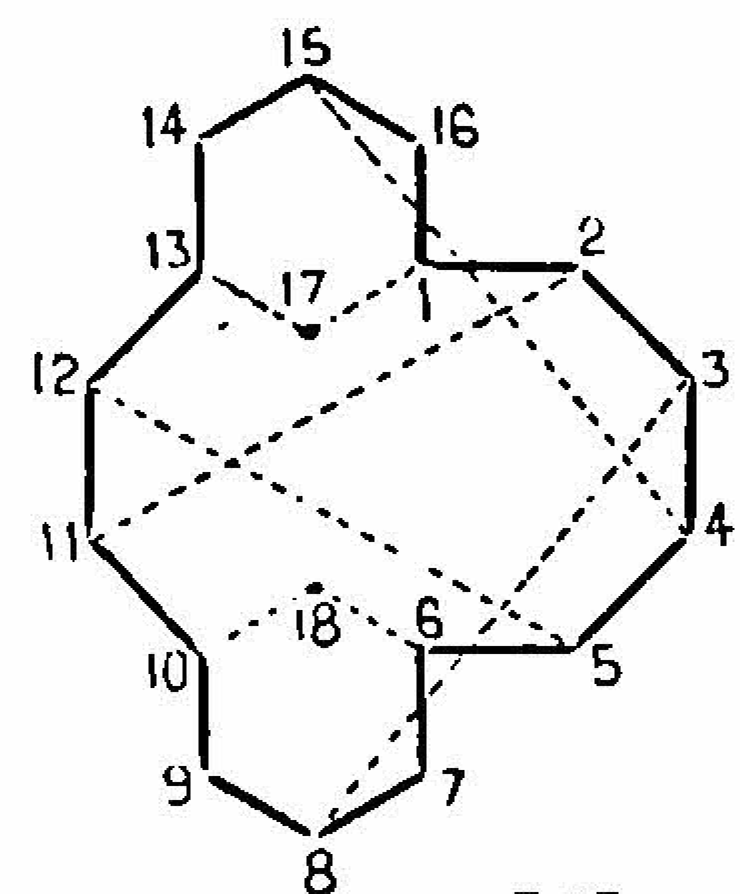

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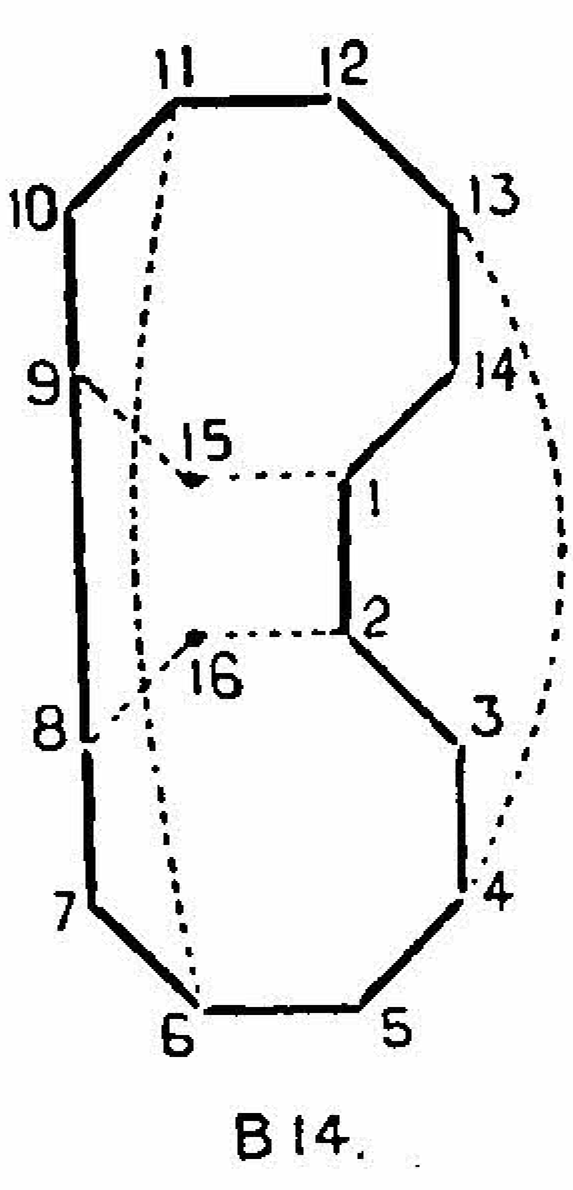

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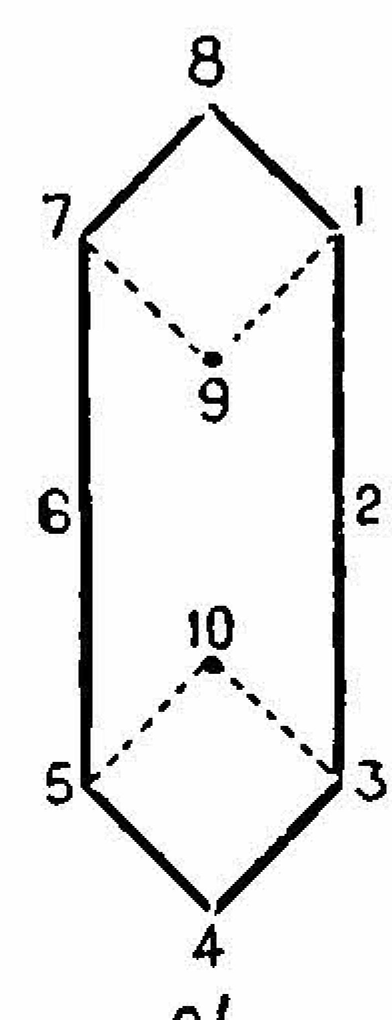
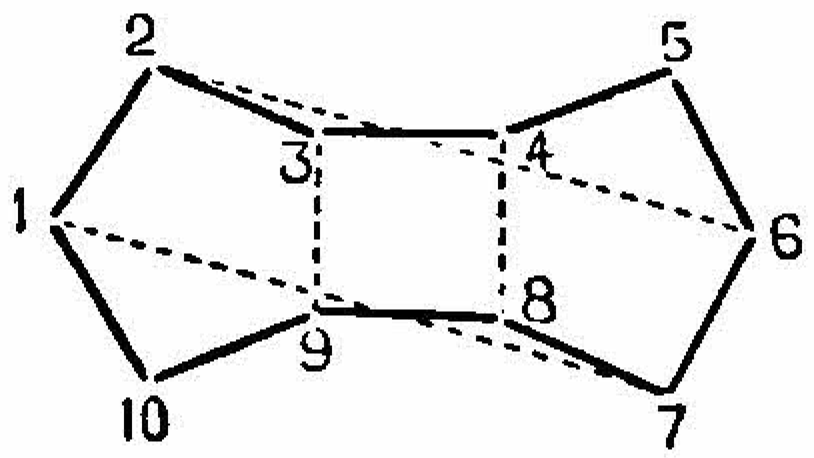


c l.

PLATE VI.



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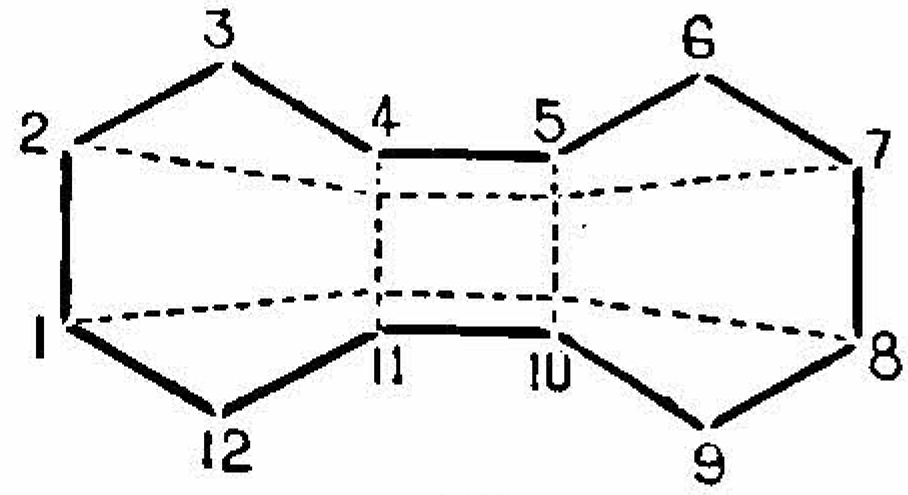

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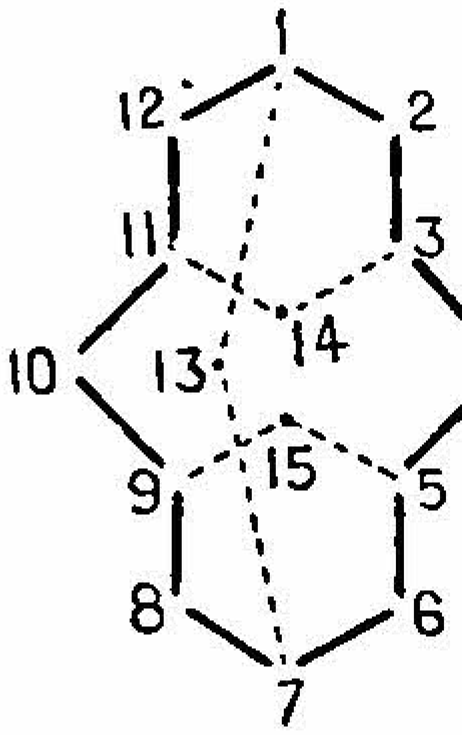

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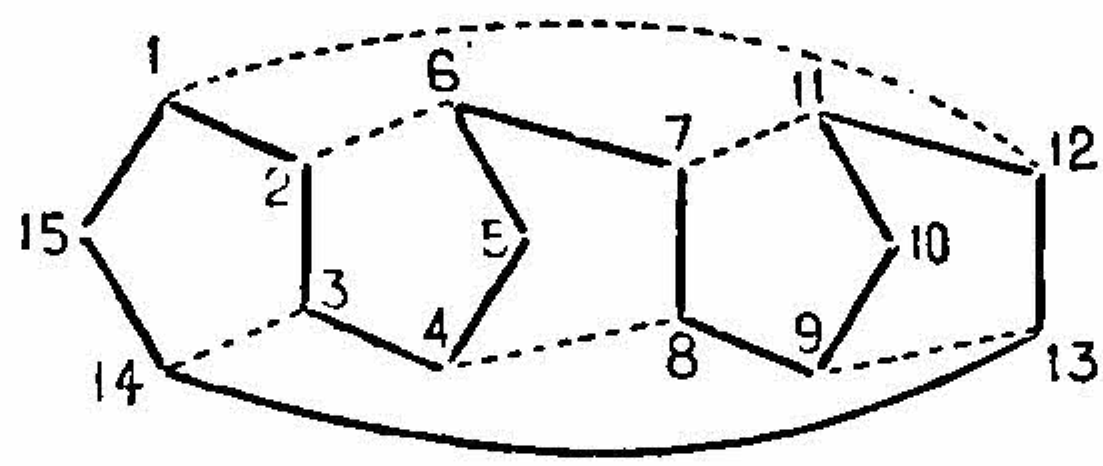

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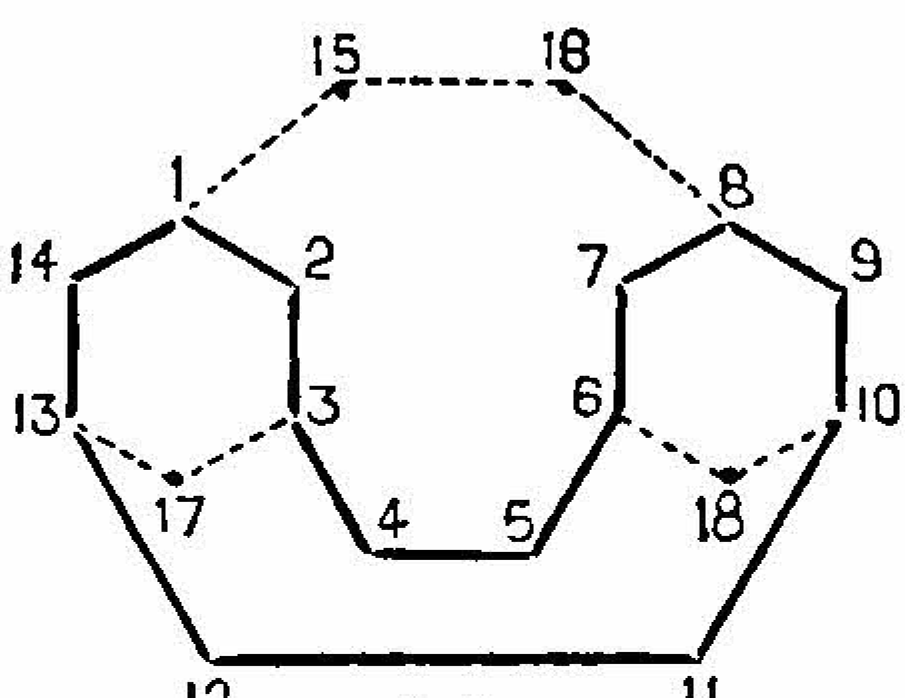

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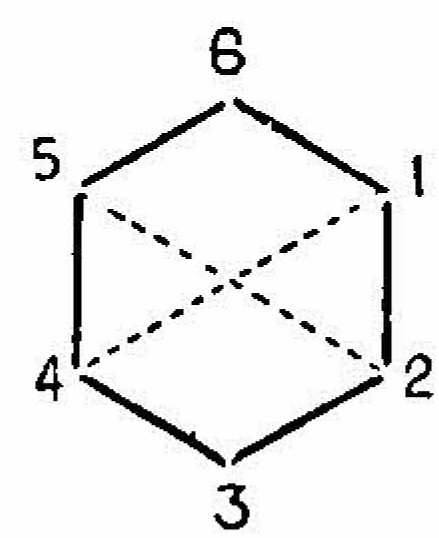

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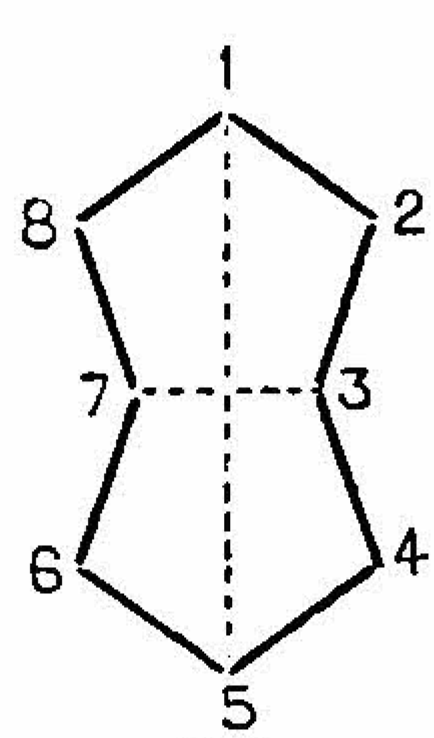

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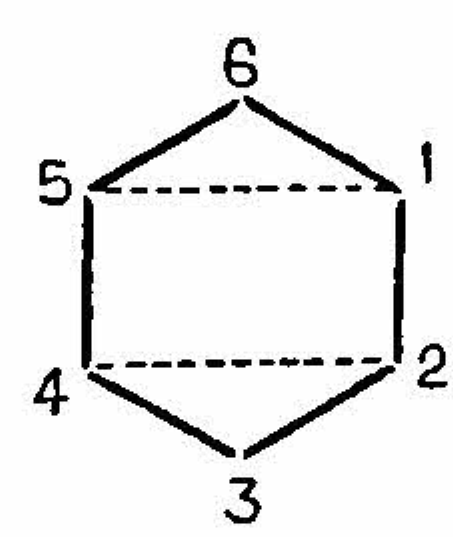

D 3.

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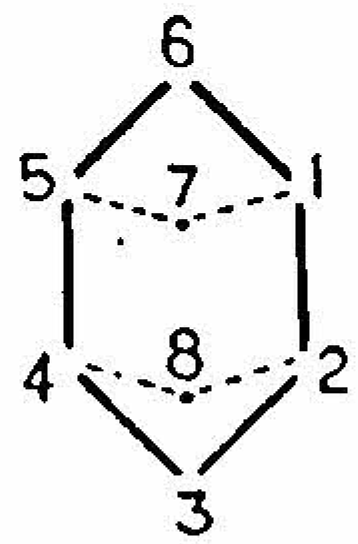

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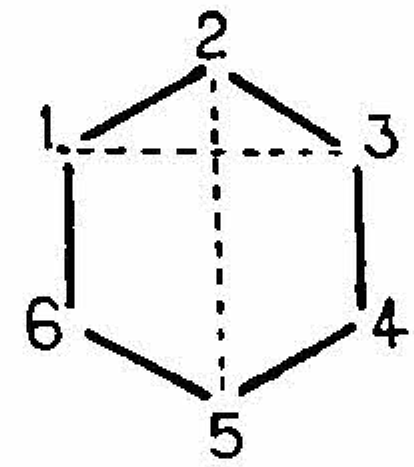

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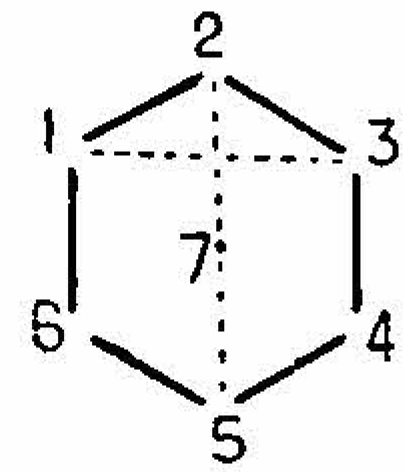

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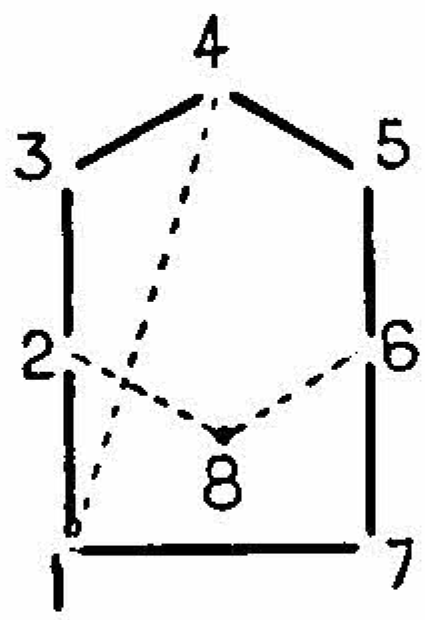

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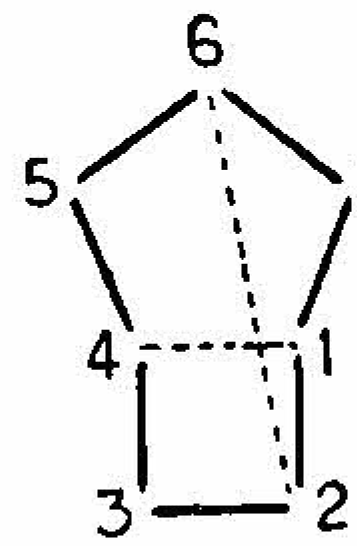

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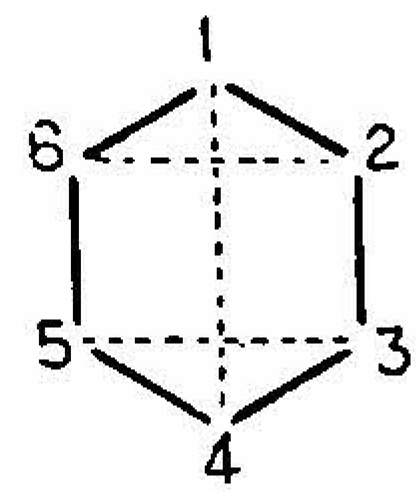

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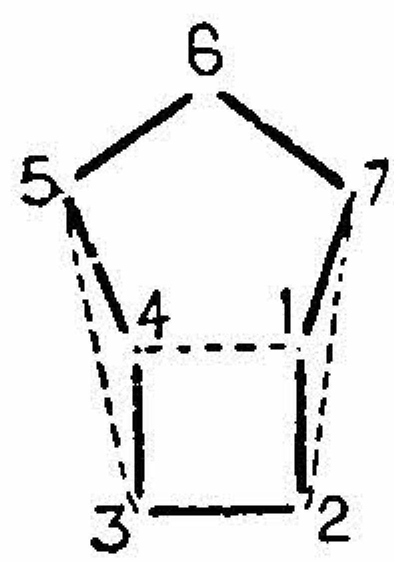

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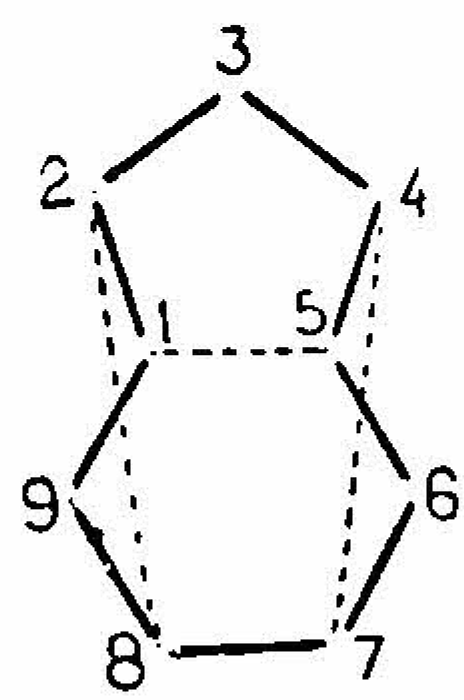

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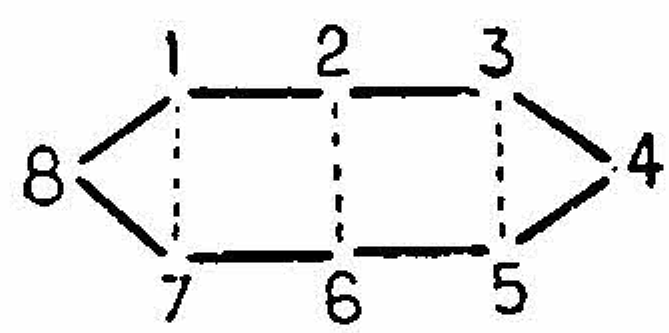

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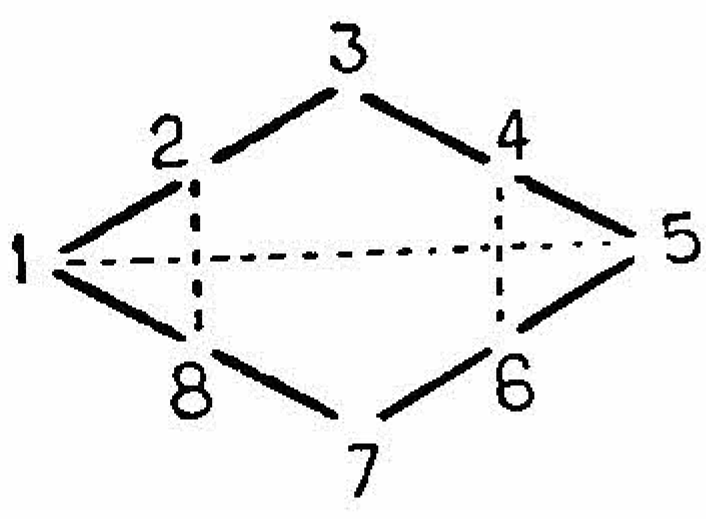

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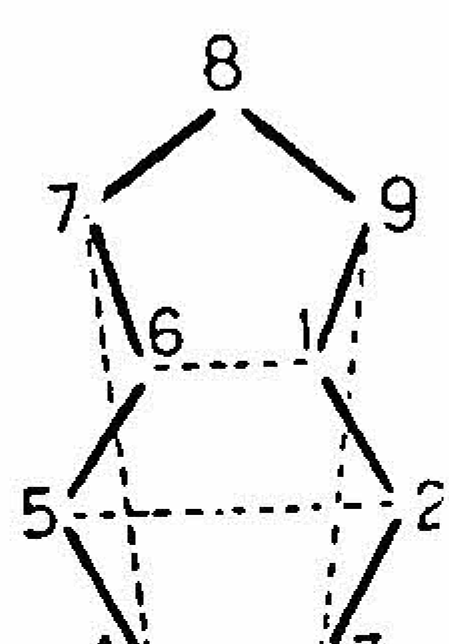

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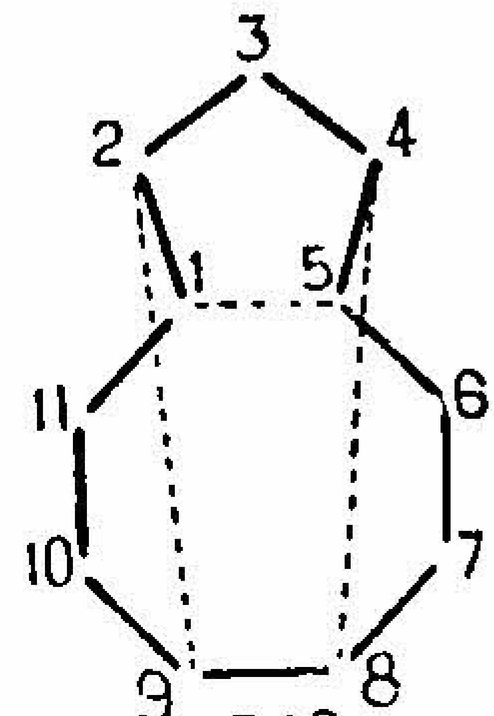

D 19

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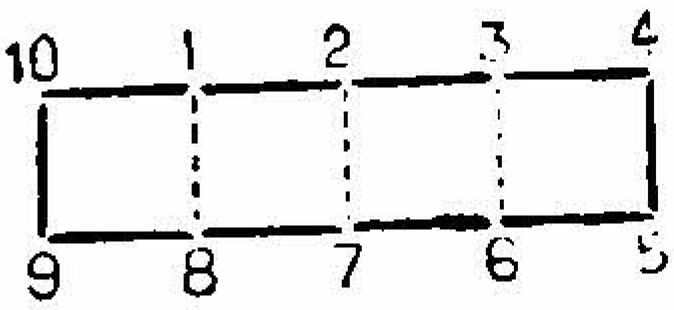

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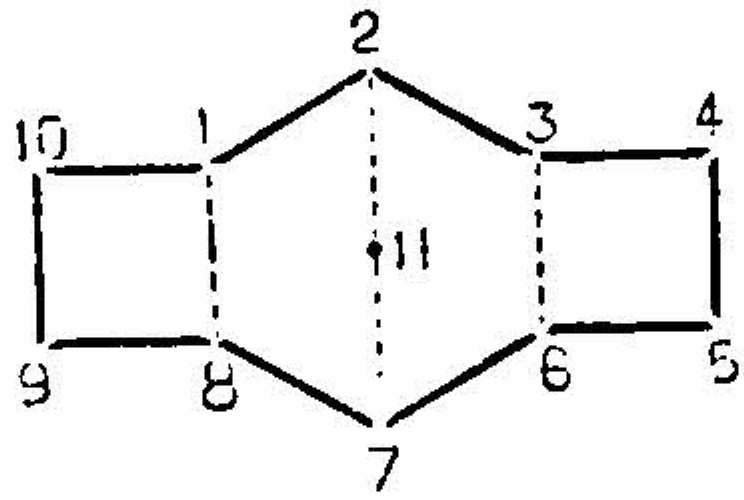

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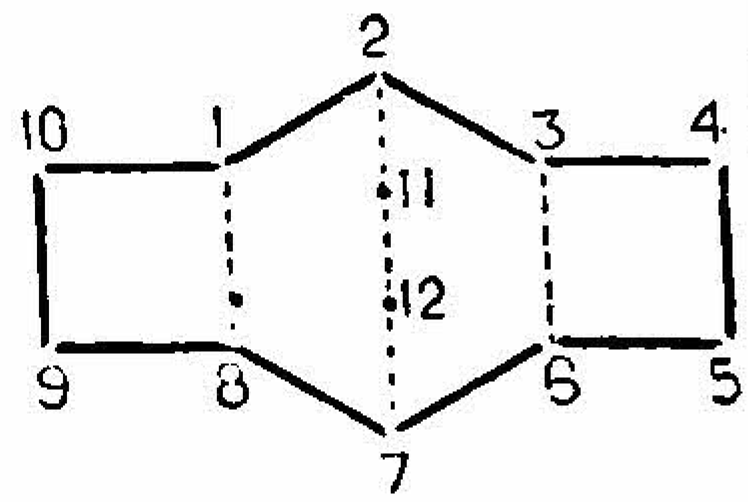

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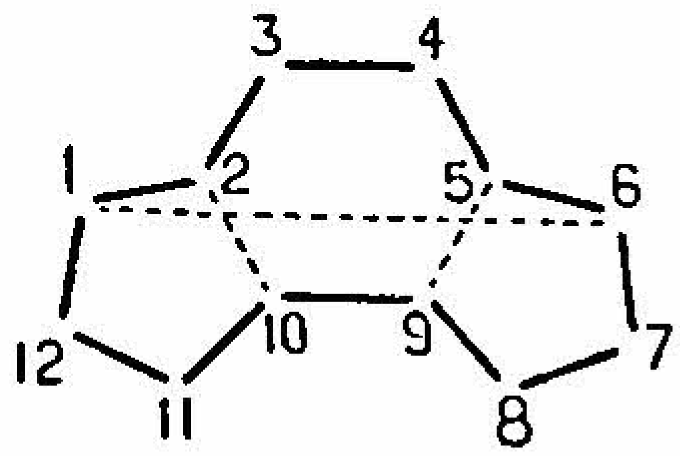

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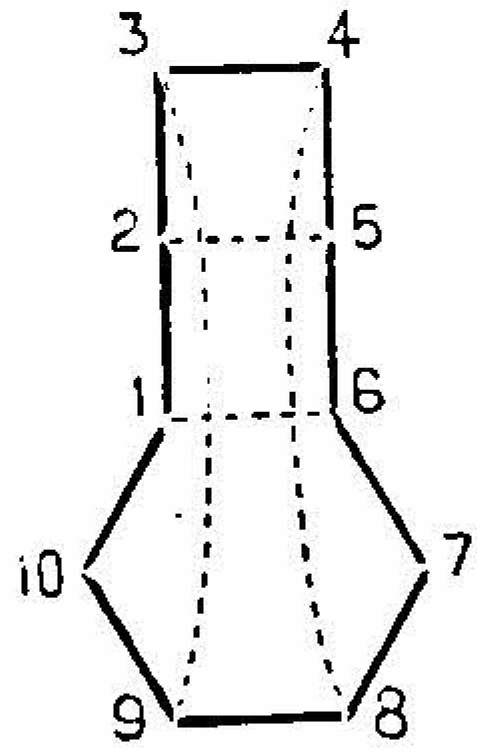

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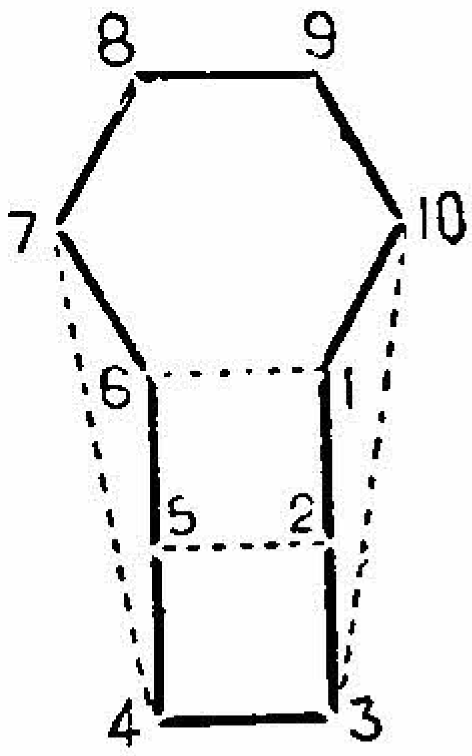

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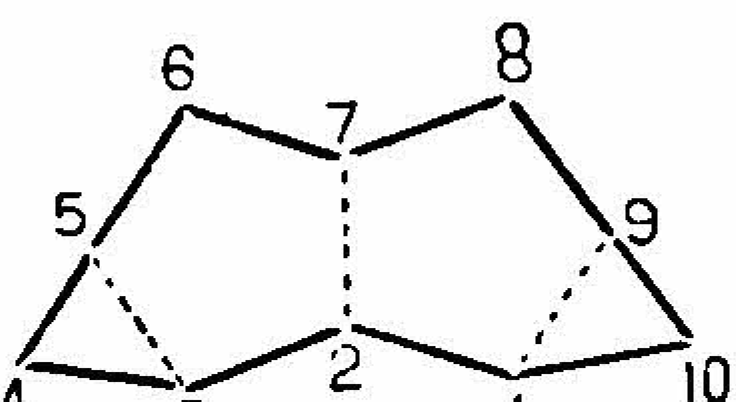

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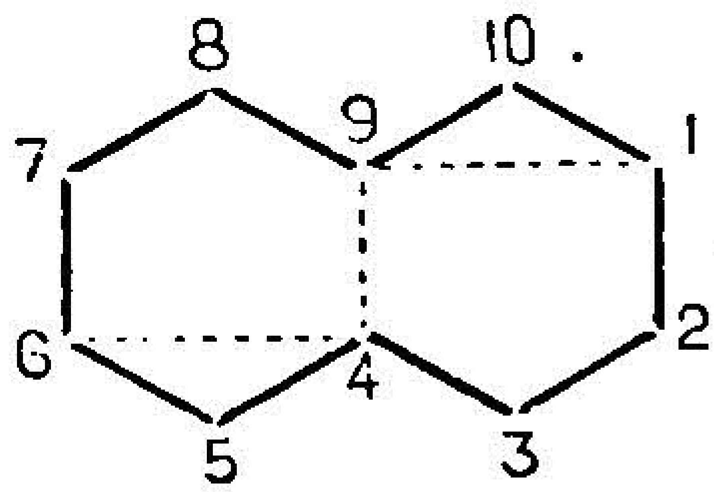

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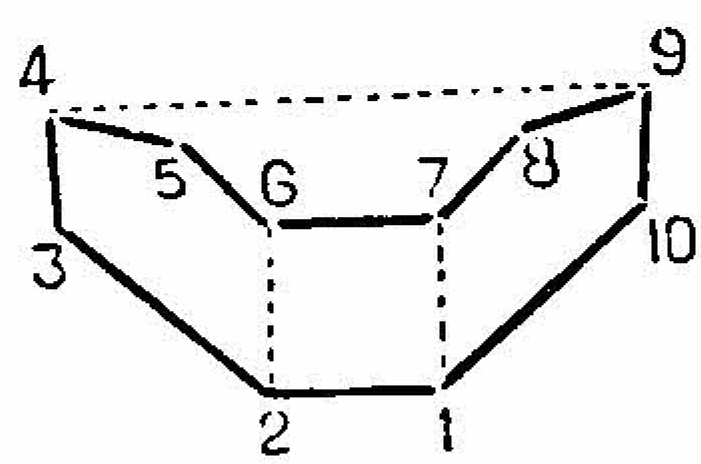

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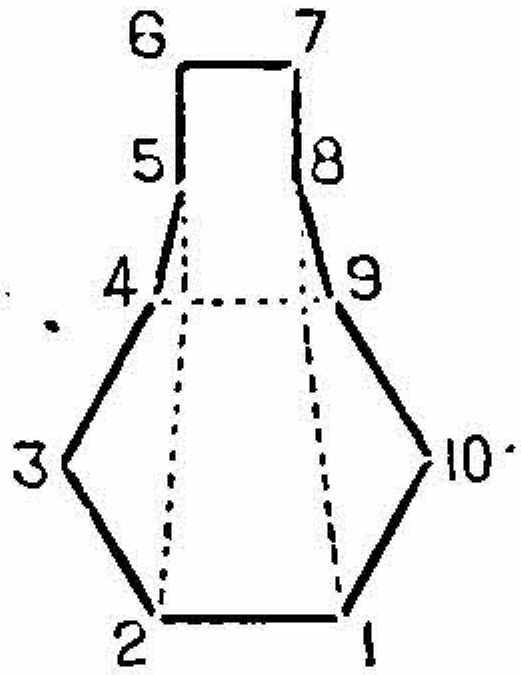

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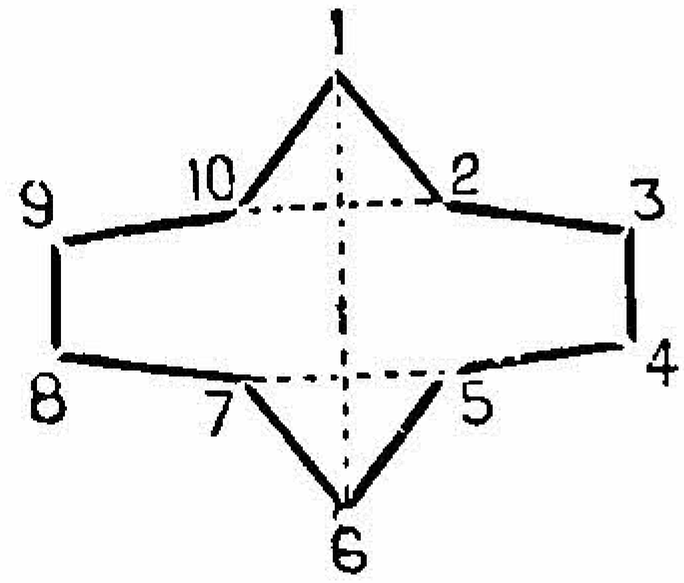

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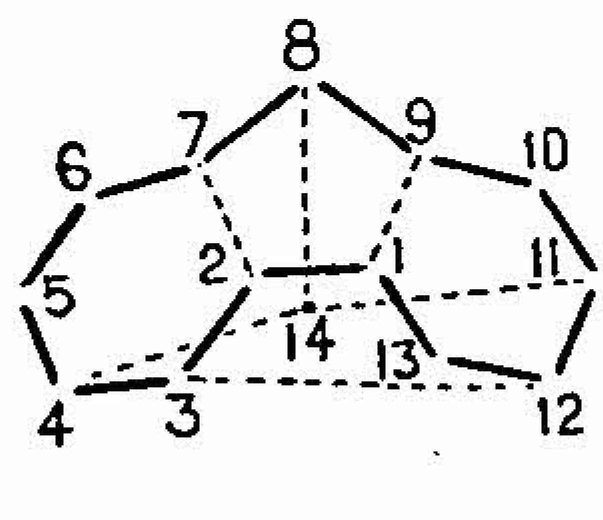

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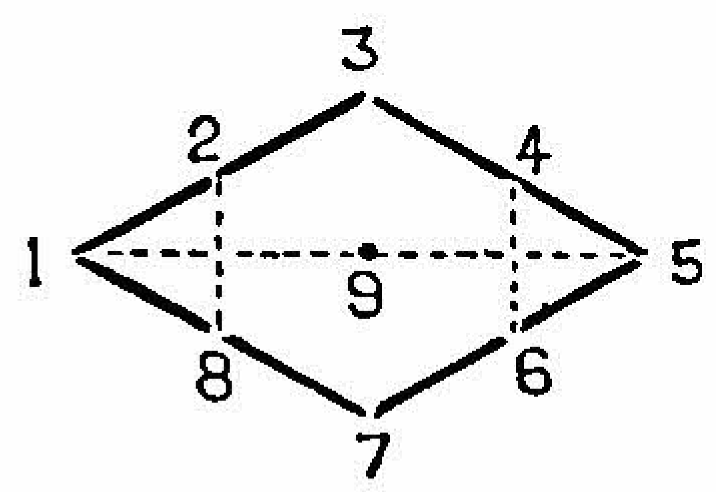

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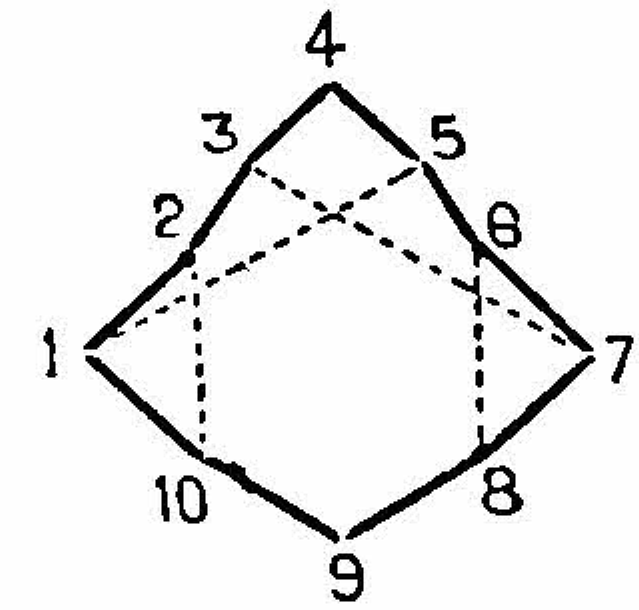

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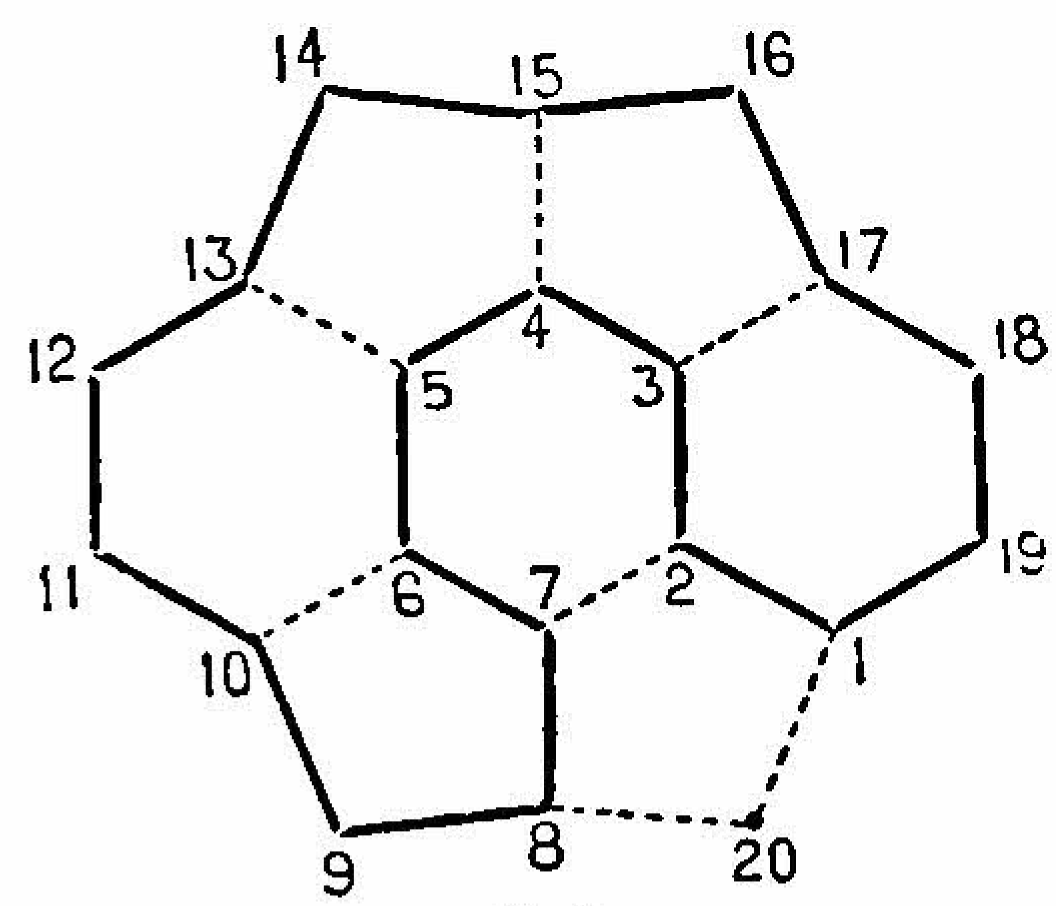

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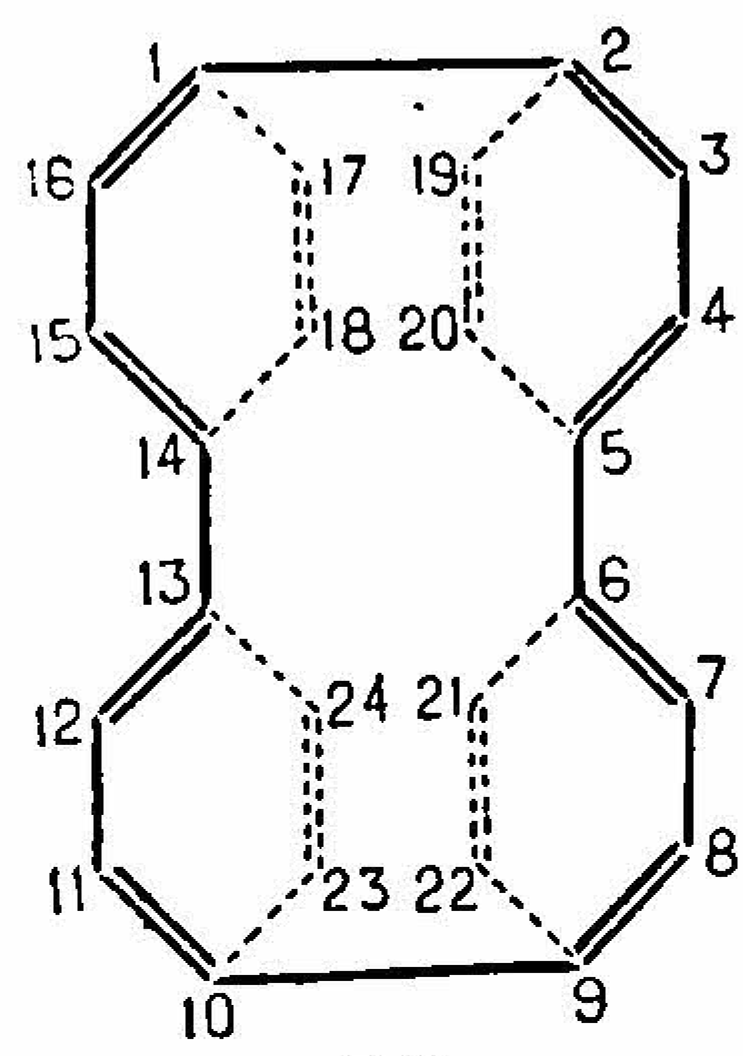

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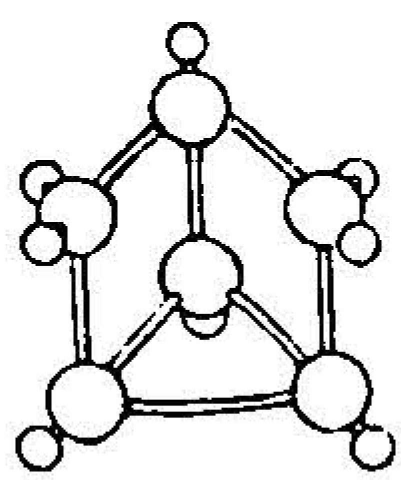

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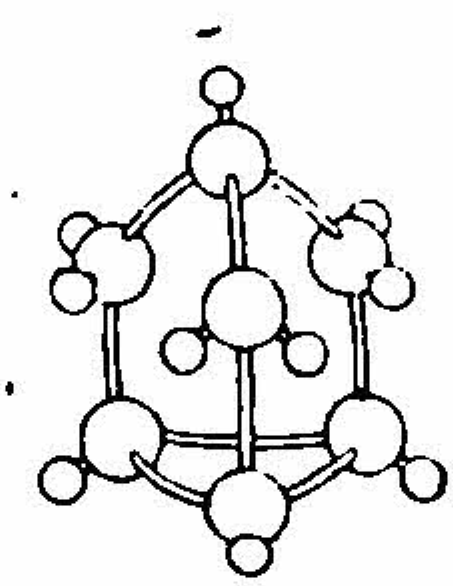

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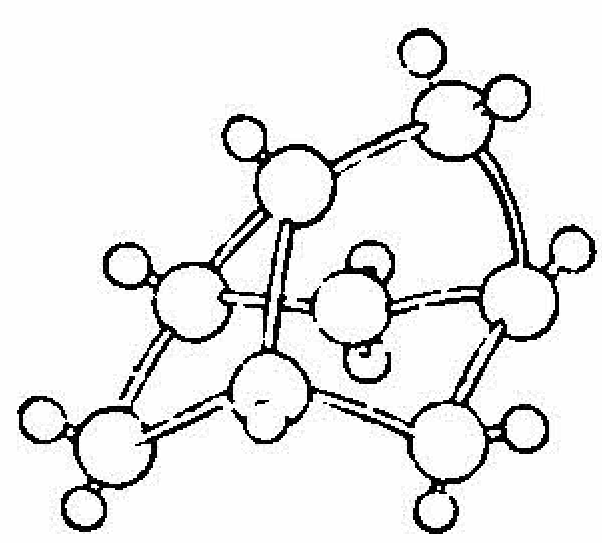

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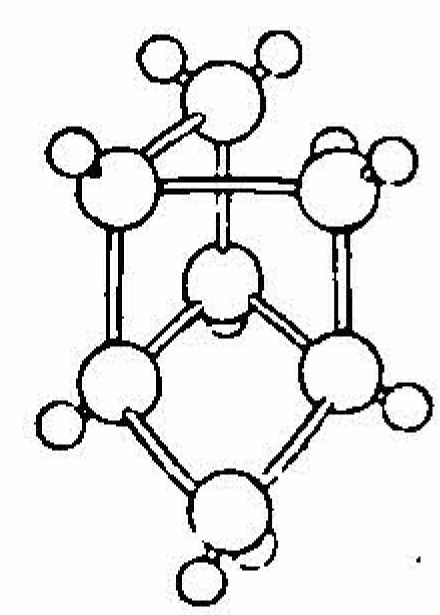

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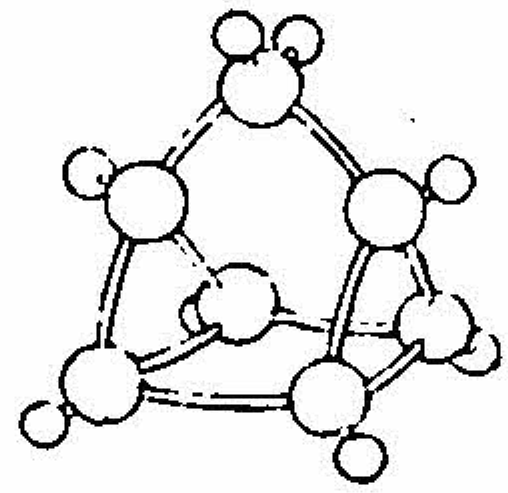

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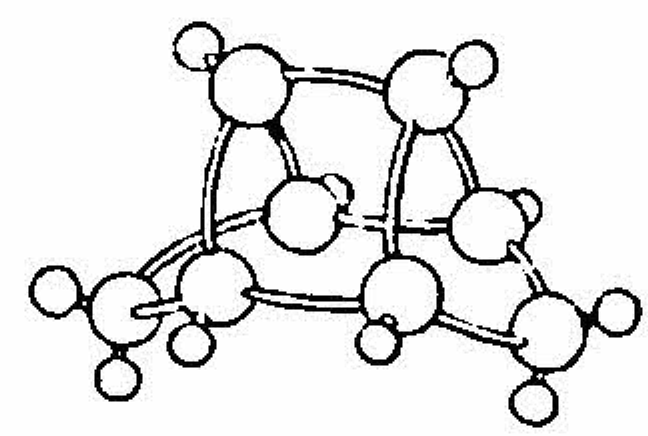

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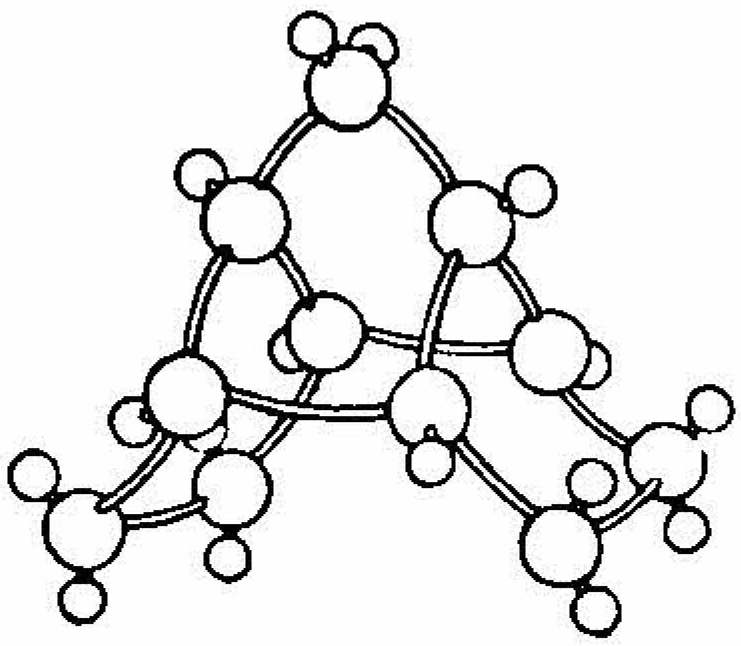

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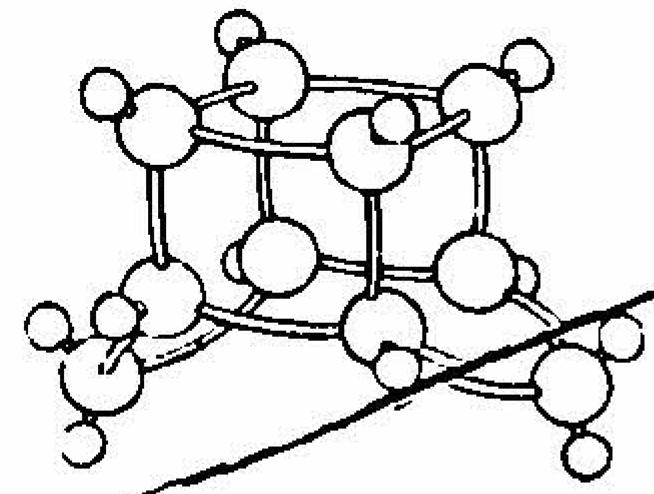

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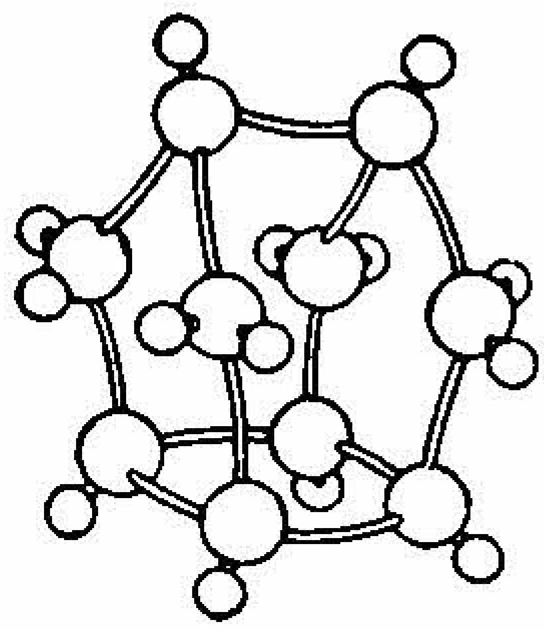

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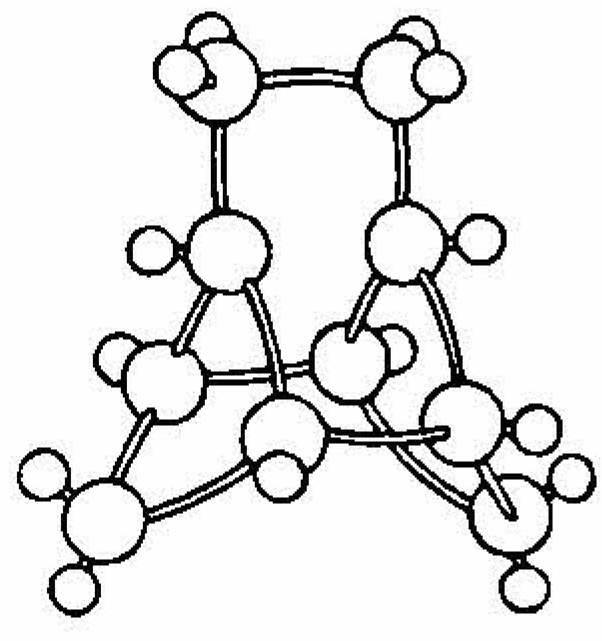

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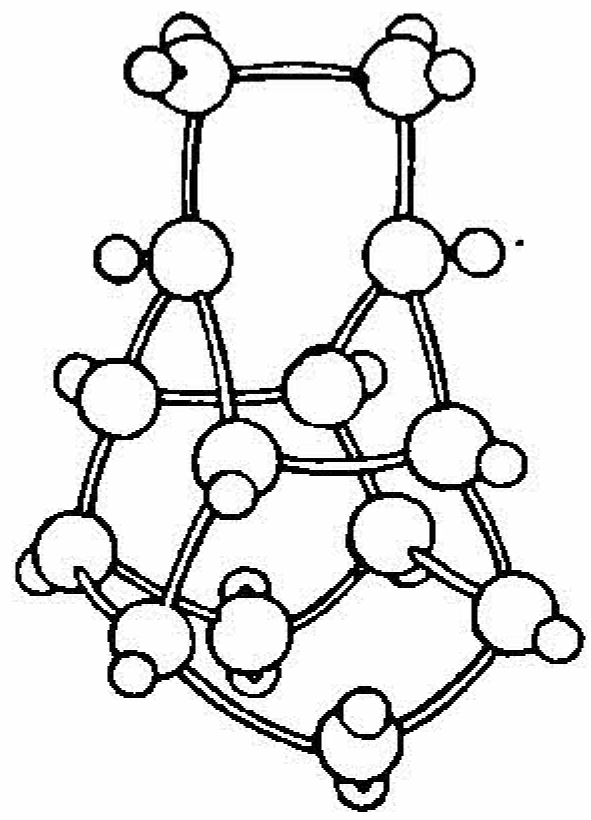

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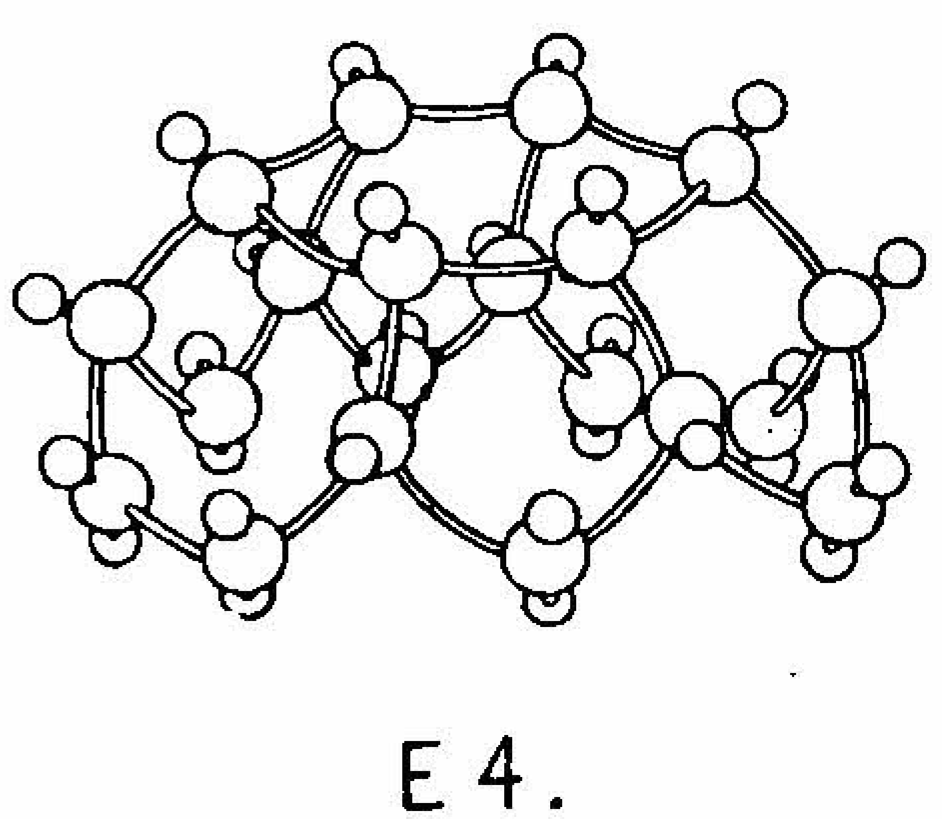

E 4.