monsanto

FROM (NAME & LOCATION) M. F. BABER - ST. LOUIS

DATE : JULY 29, 1970

cc: H. S. BERGEN
G. R. GRAHAM - NEW YORK

SUBJECT : TRANSFORMER - DIVERSIFICATION

REFERENCE :

TO :
P. G. BENIGNUS
J. G. BRYANT
R. DAVIS
R. H. MUNCH
D. A. OLSON
W. R. RICHARD

The attached are rough notes from our July 27, 1970 meeting concerning the transformer industry. The addressees were present.

Most of the meeting was devoted to listing and discussing the various insulation materials which are presently used in transformers, and the properties which are desired for new materials which might be developed.

The following two points were discussed in some depth, and may deserve further consideration:

1. A possible diversification opportunity exists if we can develop high quality, solid impregnants for paper which can be added to the paper as a liquid and then be polymerized or otherwise solidified after the transformer core and coil are assembled. We could purchase and treat paper and paperboard, and market the treated product. We could also sell the impregnants themselves, if we so chose.

   This approach is especially applicable to non-cellulosic papers. These are presently difficult to impregnate because fiber sizes cannot be reduced to desired dimensions. Consumption of non-cellulosic papers are expected to grow rapidly in future years. Capacitors and oil-filled pipe cables also should find uses for these types of impregnated papers.

2. Westinghouse is undergoing a major experimental and redesign program. New solid and liquid insulation materials are being evaluated for many types of transformers. We have not been working closely with them

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as we have had little to offer in the area of new materials with different properties. They will inform us of their needs for better materials upon completion of their analysis, which should come at about year's end.

A number of diversification possibilities relating to transformers were not discussed at this meeting. These should be covered briefly at our next meeting scheduled for 9:00 A.M., Monday, August 3, Room T-469 (not T-369 as originally stated).

Mike

M. F. BABER

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Attachment

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MATERIALS FOR TRANSFORMER

A. INSULATION MATERIALS FOR TRANSFORMERS

1. Liquids Used

Mineral Oil	- Corona at 3000v; may be good to 150°C if paper is replaced and if mineral oil cleaned up; Market about $4 $\overline{M}$.
Askarels	- Aroclor 1242, Aroclor 1254, Aroclor 1260 + TCB
Silicones	- Temperature range from -55°C to 200°C.
Fluorocarbon Liquids	- ($1.5-4.0 $\overline{M}$ specialty market, may be $1.0 $\overline{M}$ in electronic transformers). Offered by Allied Chemical, Dupont, Emerson and Cuming, 3M Co., Union Carbide and Whitford Corp.

2. Hydrocarbons, mostly from Chocolate Bayou

Alkyl benzene	- (has good properties, has been considered in cables).
H-230	- (Therminol 55, pour point of 22°F, B.P. of 670°F, 41 cs viscosity).
Ethyl Benzene	(still bottoms - flux oil) (B.P. of 490°F to 690°F, pour point of 63°F, viscosity of 37 cs at 122°F).

Aromatic Oil #1

3. Other Fluid Possibilities

Some cheap synthetic

Ethylene/Propylene copolymer (Low temp.)

Mineral Oil plus a synthetic (adjust DK for maximum impulse)

Mineral Oil plus polysulfone

Polyisobutylene fluid (low temp.)

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4. Gases and Boiling Liquids

Air, unpressurized (smallest unit if can handle voltage).

Nitrogen (pressurized) (diel. strength = 1.0)

Fluorocarbon liquids (selected for low B.P.)

Fluorocarbon and chloro-fluorocarbon gases

	BP, °C	
C_2ClF_5	- 38.7	Suppliers: Air Products, Allied Chemical, Dupont, Englehard, 3M Co., Union Carbide
CCl_2F_2	- 29.8	
$C_2Cl_2F_4$	+ 3.8	
C_2F_6	- 78.2	
C_4F_8	- 5.9	
C_3F_8	- 36.7	
CF_4	-128.0	Some use in circuit breakers and high voltage pipe cables. Dielectric strength is 2.3, use to 150°C
SF_6	- 63.8	

5. Gases Which Could Be Considered

HBr + Freons

HCl + Freons

Askarel + SF_6 (was tried, perhaps SF_6 was not soluble enough in Askarel).

Note: Gas transformers have less explosive force on arcing than liquid transformers.

On boiling liquids, must keep bubbles away from coil area to avoid corona.

6. Solid Insulation

Cellulose papers and board

High Temp. Synthetic papers like Nomex (as price comes down plastic papers may completely replace cellulose papers).

New asbestos paper by Johns Mansville (good power factor)

Other materials (see MFB report)

Plastic Films in Electronic (small) Transformers

Cellulose Acetate (Vuepak ?)	850,000 lb.
Mylar polyester	1,100,000 lb.
Polyimide	100 lb.
PTFE	700 lb.

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Slow but steady growth rate expected.

Nylon films not used, probably because of temperature. Nomex is a paper, not a film.

Additional discussion on solid and liquid insulation materials in Transformers can be found in "Electronic Transformers", H. Nordenberg, 1964; Insulation/Circuit Directory/Encyclopedia, June/July 1970; and the MFB June 22 report on the Transformer Industry.

B. INDUSTRY NEEDS

1. Less costly transformers.

2. Lower core and coil electrical losses. Better conductors and core material needed. (in cables super conductors and sodium filled cables have been considered to solve this problem).

3. Better insulation systems for underground transformers.

4. Avoid pollution problems from hydrocarbons, Aroclor, etc. Can avoid with gas-filled units if can keep units tight; but must consider cost of keeping tight, pollution from leaking gases, cost of refilling, and cost of initial fill of expensive gases if nitrogen is not used.

5. Higher temperature insulation, perhaps.

6. Insulation with a higher impulse strength so smaller transformers can be designed.

7. Method to press Nomex and other plastic papers without entrapping gas pockets and/or voids(Mica impregnation helps, at least it increases dielectric strength and corona resistance).

8. A better fire-resistant fluid.

9. A "cheap synthetic" to replace mineral oil.

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C. MONSANTO MATERIALS RESEARCH

Westinghouse suggested we develop an insulation material which would be compatible with Aroclor and would operate at 125°C. This should (according to them) allow a smaller Askarel transformer to be designed, which would be more competitive with oil units and increase Askarel's percentage of the liquid-filled transformer market significantly above its present 5-7%. The new material, impregnated with Aroclor, should have a higher impulse strength than present systems.

As a result, the following materials were investigated by Dr. Munch:

- Nomex (felt, paper, and hot-pressed paper) had good high temperature properties and was compatible with Aroclor; did not have as high a dielectric strength as would like; got voids upon hot-pressing; did not try mica-impregnated Nomex.

- Acrylan paper (polyacrylonitrile/styrene) contaminated the Aroclor.

- Polyacrylonitrile paper (from Weyerhauser) contaminated the Aroclor.

- Webril (non-woven paper) - when properly treated it was compatible with Aroclor. Not think would operate at 125°C.

- Cerrex (spun-bonded nylon 66) was so open its properties were little better than Aroclor alone. Was compatible with Aroclor after being treated and washed.

Materials investigations were suspended as a result of the PCB problem and because Aroclor 1242 was found to form explosive gases upon arcing. These problems left the future of Aroclor and associated materials in doubt.

Westinghouse is presently undertaking a large-scale redesign and development program in an effort to arrive at the optimum and least costly transformer design at various voltage levels. Westinghouse - Sharon, Pittsburgh and South Boston are all involved. The program involves computer design models and laboratory experimentation. The work should be completed by around the end of the year. We have talked with them, but have not been working closely with them as we felt we had nothing new to offer in the line of fluids or solid materials.

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One new system they tried recently consisted of a combination of Nomex, Insuldure paper, epoxy binder and Aroclor. Each material individually is compatible with Aroclor. For some reason the combination does not appear to be. Insuldure paper contains three additives which are absorbers of HCl; melamine, dicyanidiamide, and urea.

Apparently polyimide-paper has the same problem. Together they are not compatible with Aroclor, separately they are.

D. IMPREGNATED PAPER

The possibility of our supplying an impregnated paper which could be polymerized after the core and coil are assembled was discussed. Plastic impregnated papers and other materials are available, but generally they are rather stiff and difficult to work with.

In present liquid transformers, the paper is impregnated with liquid Aroclor or oil. Solids have higher dielectric strengths (up to 10,000 v/mil) as compared to liquids (ca. 400 v/mil) or gases at atmospheric pressure (ca. 60 v/mil).

If the voids in the paper could be filled with a suitable solid or semi-solid, the dielectric and impulse strengths of the paper might be improved considerably. This might allow more compact design of high voltage (eg. EHV) transformers. It also might be applicable to lower voltage units.

Some properties of the impregnant should be as follows:

1. It can be gotten into the paper without leaving voids.

2. It will solidify after the core and coil are assembled.

3. It is not soluble in the liquid phase.

4. Electrical properties should be close to that of paper (The D.C. should be 4-6 with cellulosic paper and about 2 for synthetic, plastic papers).

5. It must be compatible with Aroclor and/or mineral oil.

A similar process is used to impregnate the assembled coils of dry-type transformers with Dow-Corning's 997 silicone varnish. However, impregnation is not complete and the varnish is used primarily for environmental protection rather than for increased electrical properties.

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Possible miscellaneous products which were mentioned were TCB, solid Aroclors, shellac, cellulose acetate, liquid 1254 and chlorinated terphenyls.

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