A VERTICAL ENLARGER

NEWNES

PRACTICAL MECHANICS

9D.

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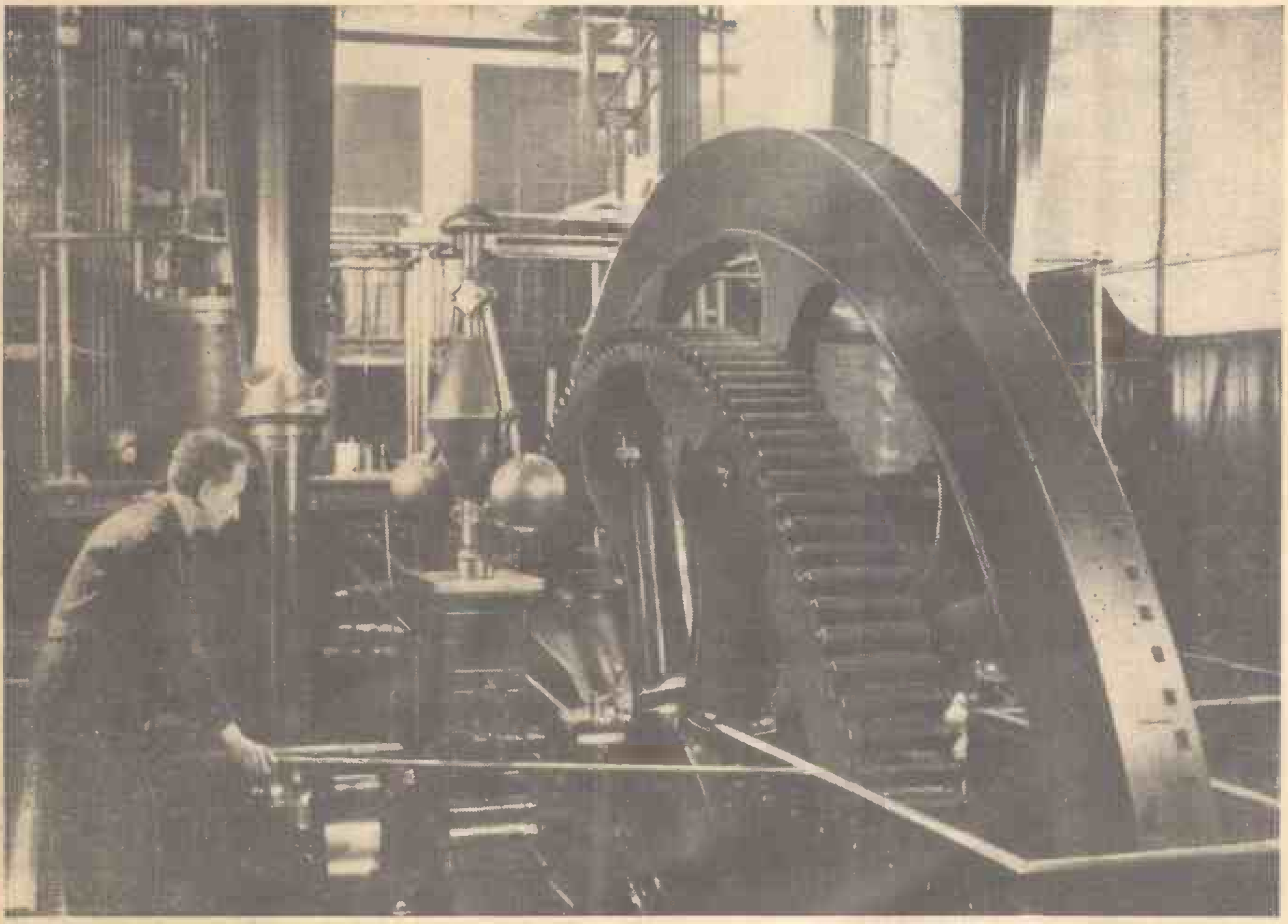
MARCH 1947



THIS TWIN-BEAM ENGINE, BUILT IN 1861, STILL PROVIDES POWER FOR A LARGE FACTORY. (See page 211)

PRINCIPAL CONTENTS

Rocket Propulsion

Early German Transonic Research : 1,500 m.p.h.-plus Project Aircraft from Bell and Douglas

By K. W. GATLAND

(*Continued from page 158, February issue.*)

Chalmers H. Goodlin, Bell's twenty-three year old chief test-pilot, hopes to fly a developed XS-1 at 1,700 m.p.h. over 15 miles up.

FOR obtaining data at transonic flow speeds, the wind-tunnel is little more than useless. There is considerable interference in the working-section between the walls and from the model supports; and hence the reason for what in comparison with the static model is a costly item of equipment, the unmanned free-flight research aircraft.

First German Experiments

First of these special types was the "Feuerlilie," developed by German aerodynamicists. Actually, this did not signify a specific machine but was a group designation which covered at least three distinct models. They were originally intended as ground-to-air missiles, and all three, the Hechte, the F.25 and the F.55, were designed by Rheinmetall-Borsig and developed at the Hermann Göring Research Institute, sunk deep below ground in the forest of Volkenrode, near Brunswick.

F.25

Driven by powder fuel, the F.25 appears to have commanded most attention and some twenty models were launched between 1941 and 1943.

The drawing (Fig. 92, top) shows the external layout and it will be seen that swept-back wings, with tip fins, were mounted mid-depth of its slim and nose-pointed fuselage. They were of section N.A.C.A. 0009, swept back at 40 degrees and set at zero incidence to the body axis. The tail assembly was rather unusual in that a separate fin and rudder extended both above and below the rear fuselage. Each carried a tail-plane, the upper one having movable elevators adjustable for each flight. The machine was roll stabilised by a gyro-servo mechanism, working through electro-magnets which moved ailerons at the wing tips.

The rocket motor, which could be either a 109-505 or 109-563 di-glycol type, delivered a thrust of 1,100lb. for six seconds. With its aid, the model was launched from a ramp set at 60 to 80 degrees and could reach a maximum speed of 720ft. per second.

Leading particulars for the F.25 are as follows: length, 6.56ft.; fuselage diameter, 9.85in.; span, 2.95ft.; wing area, 3.84 sq. ft., and the all-up weight, 264lb.

Design of the F.55

The F.55 (Fig. 92, bottom) was a larger machine and tailless, weighing 1,040lb. Its wings, tipped by large square-cut fins, swept back at 50 degrees and were 8.20ft. in span with an area of 26.2 sq. ft. The fuselage, 21.6in. in diameter, had an overall length of 15.75ft.

First tests were made using a booster rocket, jettisonable as a first stage, in addition to its driving charge—both di-glycol burning. The booster section, thrusting at 4,400lb. for six seconds, was first embodied as a fixture on the rear fuselage, but this brought trouble straight away, for unless a vertical or near vertical ascent was adopted, the missile became unstable immediately after leaving its launching ramp. The obvious remedy was to split the large boost rocket into smaller units, mounting them as close to the aircraft's c.g. as possible, and this was done, using four 1,100lb. thrust rockets with satisfactory results. One such model, in fact, having risen to 15,700ft. from a launch at 70 degrees, flew for 4.66 miles. Its final speed (at the time of impact) was M=1.25.

Later flights were planned in which a liquid-fuelled power plant displaced the second stage powder rocket and using 90 kg. of oxygen and 50 kg. of alcohol, it was found that a thrust of approximately 1,100lb. could be maintained for 25 seconds. A di-glycol boost rocket contributed 6,600lb. thrust for the first two seconds of flight, whereupon it automatically released and dropped off. The bi-fuel unit then, thrusting on its own account, would take over and the machine flying under the control of its auto-pilot usually remained stable throughout its complete run. Any rolling tendency was continually and automatically corrected by deflection of the ailerons. Fore and aft stability was said to be particularly good.

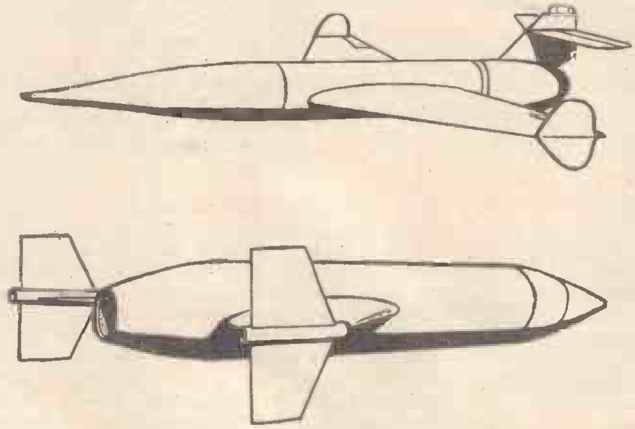


Fig. 92.—Two models of the "Feuerlilie" series, the F.25 (top) and the F.55. Flares, fitted on the fin or wing tips, were sighting aids for ciné-theodolite operators.

Hechte

Hechte was actually the first of the "Feuerlilie" series and it might well have taken its place in the Rheinland defence system had its development not been guided into other channels. The ground-to-air weapons that followed the early "Feuerlilie" models, however, embodied many of the features proven in the Hechte and F.25, and much of the data found its way into the hands of the full-scale aircraft designer.

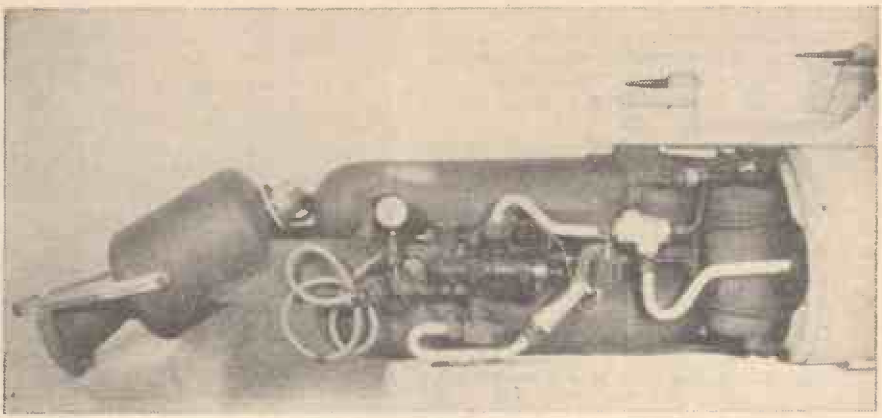
The Hechte and the F.25 appear to have been almost identical in both size and shape, the only main difference being the power unit. Here again a bi-fuel propellant was the integral driving force, though not as in the F.55. The Hechte used a "cold" system operating on T-stoff and Z-stoff (80 per cent. solution, H_2O_2 and calcium or sodium permanganate), which gave 132lb. thrust for from 20 to 25 seconds. The maximum speed attainable was about 920ft. per second, and as with the F.25 and F.55, roll stabilisation was effected by ailerons through a gyro link.

Some General Particulars

Work on the larger model (the F.55) had only just commenced when Germany collapsed, and there is no evidence of the liquid-fuelled version having flown, though several were almost completed. The solid-fuelled model was further advanced, and there are several complete examples. One of these, tested by technicians of the U.S. Army shortly after the occupation, is said to have risen successfully and to have remained stable and on course up to its maximum Mach number of 1.25, despite the conventional wing-section (again N.A.C.A. 0009) and normal type ailerons. This particular model weighed 1,000lb., and its di-glycol rocket, fitted internally, developed fully 13,000lb. thrust. From a comparison of these figures and those given earlier, it would seem that there were several size charges specified for this type.

A ciné-theodolite was employed to follow the course of these midget research missiles, though this system seldom proved reliable. The plotting involved a double differentiation which, despite the greatest care by both operator and calculator, was a very inaccurate process, and although the German technicians strove to improve the mathematics of the problem, by analytic differentiation and the fitting of high-degree polynominals to the trajectory curve, they still could not better their results. The ideal solution, that of transmitting data from the model "air-to-ground," was not practicable at the time of the experiments although research was proceeding at the D.V.L. (Deuteches Versuchsanstalt für Laftfahrt) in an attempt to perfect a radio transmitter for this and similar projects.

Since the war's ending, Allied technicians have perfected the "telemeter" with which it is possible to check with unparalleled accuracy, and at long range, the performance of pilotless missiles and aircraft. Each Vickers-Armstrong transonic model embodies one of these units capable of transmitting six instrument readings *simultaneously*. The data thus obtained has no comparison with that recorded in Germany during the war years and there is much to be expected from its further use in manned aircraft. This will be all the more apparent when full details of the Bell transonic experiments can be published.



Forerunner of the bi-fuel rocket engines used in the "Feuerlilie" models was the T-stoff and Z-stoff motor of the Henschel H.S. 293 "glider bomb." It developed 1,500lb. thrust for 12 seconds.

XS-1, First Tests

Latest news of the Bell XS-1 supersonic research aircraft is that a first flight under power has already been made. Others, in fact, may have already taken place by the time these words are in print.

Taken up beneath a specially adapted B.29 "Super-Fortress," the machine was cast off at 25,000ft., and then releasing propellant to *one* of the four combustion chambers, the pilot succeeded in reaching a maximum level speed of 550 m.p.h.

In announcing this Major E. J. Huber, of the Headquarters Army Air Forces, gives the designed top speed as 1,700 m.p.h. at an altitude of 80,000ft., with the maximum thrust available from the four-unit bi-fuel rocket engine, 6,000lb.—1,500lb. each chamber.

Design Features

Like the Miles M.52 project, the XS-1 has a ballistic-shaped fuselage and no wing sweep-back. Basically, the difference between these two designs is not great, though, naturally, as one was "jet" and the other is "rocket," the similarity remains only in the exterior shape. Actually, the fuselage of the Bell machine is rather more plump looking than its British counterpart, which is due to the need to provide tankage for the rocket propellant, 8,177lb. of liquid oxygen and alcohol.

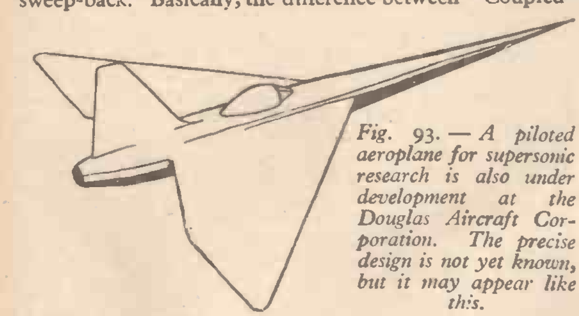


Fig. 93. — A piloted aeroplane for supersonic research is also under development at the Douglas Aircraft Corporation. The precise design is not yet known, but it may appear like this.

The overall weight of the prototype (fully fuelled, all test equipment installed and with pilot) is 13,069lb. For all that, it is not a big aeroplane, as will be observed from the photographs; the length of the first test machine is 31ft.; its span 28ft., and the height (from ground to fin tip) 10ft. 10in.

There are apparently to be at least two of these research aeroplanes, the first a "flying test-bed" for the second. The earlier version, moreover, will not be capable of reaching the speed for which it was designed because of the substitution of an alternative power unit.

A Gas-charged Engine

Originally, the engine for the prototype was to incorporate a fuel system similar to those employed in the Walter bi-fuel units, in which the propellant would be forced for combustion by a turbine driven pump. A series of design problems has unfortunately delayed the development of this particular item, and as it was obvious that the machine would be complete in all other respects long before the pump and ancillaries became available, it was decided to install an entirely different system. The method adopted was "gas charging," an arrangement reminiscent of the early German "Mirak" and "Repulsor" experiments, in which gaseous nitrogen, contained under high pressure, is used to force both fuel and oxygen from their tanks into the combustion chambers.

The gas pressurised system is naturally inferior in many respects to the mechanically actuated feed. In the prototype machine, the motor is limited to a duration of only 2.5 minutes when operating at full thrust, whereas with the turbo-pump, its maximum power could be maintained for 4.2 minutes. Coupled with this, the top speed attainable with the alternative power plant is estimated to be 1,000 m.p.h., at 60,000ft., instead of the 1,700 m.p.h. velocity at 80,000ft., as originally specified. In addition, the rate of climb claimed for the machine when fitted with a turbo-pump, 45,000ft. per minute, falls off to 28,000ft. per minute when the pressurised engine is substituted.

An 8g Pullout

When Bell Aircraft Corporation first undertook the contract for a supersonic research aeroplane—and that was in the spring of 1945—the following minimum performance requirements were specified. First, an 8g pullout at an indicated air-speed not exceeding 500 m.p.h.; then, an 8g pullout at minimum speed; a proof of the specified endurance at rated thrust, and take-off (from the ground) and climb to 35,000ft. under its own power. Finally, the machine must respond satisfactorily to control at Mach=.80.

These characteristics are now being proved. Afterwards, the 'plane will be accelerated by stages into the transonic speed zone and then, if everything goes well, the throttle will be opened wide in an attempt to confirm the designer's most ambitious estimate. This does not necessarily imply that the same basic design as recently tested will remain unaltered at transonic and supersonic speeds. The probability is that several modifications (principally in wing form) will be embodied as fresh data is brought in from each successive test flight.

The pilot's task under transonic flight conditions—when his attention must be one hundred per cent. on his controls—is considerably relieved by the telemeter, which transmits readings of air-speed, acceleration, aileron position and elevator position to a ground station throughout the entire duration of the test.

Control and the Strength Factor

An interesting feature of the control system is that the setting of the tail-plane can be adjusted during flight, and as this might normally prove hazardous at transonic speed, special flutter dampers have been designed to minimise the danger from this source. The movement is brought about by a powerful mechanical actuator. For the rest of the controls, they are apparently orthodox.

During the early phase of testing, the XS-1 will be checked comprehensively by officers of the National Committee for Aeronautics. One of their instruments is an oscillograph with which they will be able to determine the strains sustained by structural members of the wing and tail. The normal pre-flight inspections, too, will be carried out with infinite care, for there can be no room for oversight of the slightest defect. At the speeds this machine will fly, nothing can be left to chance and the ground personnel have a great responsibility.

The XS-1 has been designed to withstand 18g. (or an acceleration of 18 times the force of gravity), and clearly becomes the strongest craft ever to fly. The wings, for example, have a skin *machined* from aluminium alloy, having a root thickness greater than ½in., tapering off to about ⅛in. at the tips. Its limitations, in fact, are much more in the make-up of the pilot than in the structure of the machine.

The Pilot

The man whom it seems will be the first to outfly sound is Chalmers "Slick" Goodlin, Bell's twenty-three year old chief test-pilot. He succeeds Jack Woolams who was killed on August 30th, 1946, when a special P.39 racing 'plane which he was grooming for an air race crashed out of control into Lake Ontario. The reason for this most unfortunate mishap is given as tail failure.

Goodlin, a native of Greensburg, Pa., learned to fly at the early age of sixteen, later serving with the R.C.A.F. and the R.A.F. from February, 1941, before his transfer to the U.S. Navy in December, 1942. After his honourable discharge from the Service, he joined Bell Aircraft Corporation, and has been test flying since January, 1944.

A Douglas Project

News of progress with the XS-1 is followed by rumours of another research aeroplane, similar in purpose but very different in design, a project by the Douglas Aircraft Corporation. The machine is said to be rocket powered and as nearly a "flying-wing" as it is possible to obtain in a small high-performance type.

Actually, the need for containing comparatively large proportions of rocket propellant makes some form of fuselage essential in these thin-wing research aircraft; and then there is always the installation of pilot and controls to be considered. The Douglas project, in all events, is mainly wing, but with a slim pencil-like fuselage which projects for some distance beyond the root leading edge, tapering away to a point at the nose. The body form is naturally less slim toward the rear where the pilot is accommodated, presumably along with the main tanks and rocket motor. A single vertical fin and rudder emerges conventionally from the rear fuselage and there is no tail-plane.

The above few particulars of what promises to be an interesting aeroplane are indicated pictorially in Fig. 93. The drawing is not intended as an accurate impression of the design, but rather to illustrate the likely arrangement of such a machine as the one described.

The reason for the length of fuselage forward of the wing can be explained quite simply. At trans-sonic speeds, the highly refined nose will have the effect of breaking down the shock "front" so that the air accruing in the conical bow wave thrown off from that region hits the leading edge of the wing at considerably reduced velocity. The reduction in flow speed is further assisted by the pronounced sweepback of the wings with the result that the overall drag is greatly decreased and the lift suffers not so drastic a drop. Stability also derives a benefit in that change in trim during travel from one speed zone into another is not so marked. At least, that is the theory!

The "needle-sharp" nosing on a swept-back layout should prove effective in countering at least some of the more major problems which will arise when pilots come fully to grips with sound. It will be interesting to learn more of this Douglas venture and also to discover the truth of a report that most of the main U.S. aircraft builders are actively preparing programmes of research which call for "faster-than-sound" piloted aircraft.

(To be continued)

The prototype Bell XS-1 with which it is hoped soon to reach 1,000 m.p.h. at 60,000ft. Its engine comprises four separate combustion chambers—each capable of 1,500lb. thrust— d operating on only one, the machine has already flown at 550 m.p.h.

Glues, Cements, and Adhesives—2

Cold Glues, Pastes, Gums and Their Uses

By "HANDYMAN"

(Continued from page 120, January issue)

BY the word adhesive I refer to all such "sticky stuffs" as employed for uniting paper, cardboard, leather and smaller wooden objects to each other, and, naturally, the liquid and other cold glues which ordinarily would have been considered in the last article may be classified with the adhesives: the gums, the liquid fish-glues and starch pastes.

Liquid Glues

There is nothing much to say about the making of these glues, except that they are derived from bones and offal of fishes, and that the edible isinglass is a highly refined product made from selected parts of the fish, bearing much the same place in relation to common fish-glue that gelatine does to animal-glue. Isinglass, however, is sometimes used for the finer cements, and is therefore not an adhesive in the ordinary sense of the word, except where it is used in the making of "court plaster," an adhesive silk for cut fingers. Liquid fish-glues are supplied in collapsible tubes in all sizes and qualities and under various trade names. Seccotine is the forerunner of this most convenient form of adhesive, and a small tube is obtainable for a few pence.

The liquid glue is known under the name of "Croid," and is a quality of cold glue which, besides having a general utility, is to be recommended for small joinery and other woodwork where a small quantity of the agglutinant is required at a time. It is excellent for model-making purposes.

Using Liquid Glues

As in the case of hot glues (carpenter's hide glues) the minimum amount of cold glue should be used in making a joint, and perfect contact between the two parts is essential to the strength of the job. Rubbing the objects together to exclude the superfluous adhesive is therefore recommended. If there is bad contact between the united parts, the area of the exposed glue is considerable and dampness in the atmosphere can more easily penetrate and weaken the joint. This may not be quite so serious a matter with glues of the nature of "Croid" or "Seccotine" as with carpenter's glue, which is most susceptible to atmospheric changes, but there is bound to be some detrimental action on the adhesive if the joint is not a close one. Grease is an enemy of all adhesives, and therefore surfaces which are to be attached to each other should be free even from the natural oils which are present on the fingers. In winter, cold glues are more viscous—even hard—and if, when the tube is squeezed, the adhesive comes out in a sort of crystallised form, it should not be used without slightly heating. In a cold room, or on a winter's day, it is best to place the tube of adhesive in a cup of hot water for a few minutes before using. Seccotine tubes are usually supplied with a metal peg with a looped handle end, which is replaced in the nozzle after use. This is the simplest and best device to prevent loss of glue and to ensure a ready flow when the glue is required to be used again. Where this sort of stopper is not provided, as in the cheaper qualities and sizes, a small nail or a stout household pin will serve the same purpose.

Pastes

These are usually made from one of the flours or starch and there are innumerable recipes in common use. Dextrine is a manufactured substance which is almost identical with starch and is sometimes termed "British Gum." The granules in starch and flours are insoluble in cold water, but when heated with water of a temperature of about 75 deg. Fahr. these granules split up and adhesive "glutens" and "albumen" are formed. Both these substances possess powerful adhesive qualities, and the paste is of a double tenacity when they are both liberated. Decomposition of flour and starch pastes is due to the fermentation of the cereal constituents, and therefore preservatives are necessary. Pastes made from farina (potato starch) are not so strong as wheat or rye flour pastes, and sometimes the addition of one of the glues is resorted to. With the hide glues such a paste is more liable to putrefaction. The mixing of pastes with silicate of soda (common "water-glass" or "preservatives") can be tried, but the difficulties of keeping them are increased. Such pastes tend to liquefy when they are put into closed retainers.

The preservatives for pastes are carbolic acid, oil of cloves, camphor and other essential oils. In using that powerful disinfectant, "Lysol," as a preservative in home-made flour paste, I found that it destroyed the adhesive value of the paste—especially if the quantity was overdone—and turned the paste quite brown. I now use nitrobenzine. This is a chemical strongly smelling of almonds and is an admixture to many brands of office pastes.

Cold-water Paste

Liquid ammonia and other alkalies have the power of causing such separation, and wheat, flour or potato starch can be converted into a mass of stiff paste, which will dry up. The resultant horn-like mass will not decompose and can be ground up into a powder. This powder, usually sold as "cold-water paste," can then be mixed with water into a paste as required. The only drawback to this stuff is that the presence of the strong alkali may cause the paste to adversely affect coloured objects.

(To be continued)