CHAPTER 3

FORMULATION, PRELIMINARY SCREENING AND RHEOLOGICAL STUDIES.

3.1. Experimental Procedures

Recently water washable bases and o/w emulsion bases have become extremely popular as they have been observed to import on the incorporated drugs and advantage of exerting better therapeutic effect. The bases prepared from polyethylene glycol of different molecular weights, Carbopols, pectin, etc. are elegant in appearance, non staining or slightly staining in nature and hence more acceptable to consumers. However, these bases are not commercially manufactured and used in this country to a large extent, for number of reasons such as - (i) the chemicals required for preparing these bases such as polyethylene glycols of different molecular weights, Carbopols, pectin, etc. are not manufactured in sufficient amount to meet the demand of the country; (ii) the polyethylene glycols and pectin which are locally manufactured are not available in grade of purity required for pharmaceutical standards; (iii) the method of preparation of these bases are not simple and involves many complicated procedures; (iv) the long term and short term physical and chemical stability of these bases and their incompatibilities with number of drugs used topically are not good. Even paste prepared from starch may lack in stability. Bases prepared from sodium CMC also may lack in good appearance.

The primary purpose of this investigation was to study the specific pharmaceutical applications of anionic and nonionic surfactants through an evaluation of the hydrophilic ointment bases. Number of ingredients which are mentioned previously were selected for the formulation of cream bases, on the basis of their chemical form, purity, potential stability, general use, low toxicity and availability. One hundred and ten bases were prepared and subjected to complete evaluation employing the following procedure.

3.2. First Screening Evaluation

The purpose of this evaluation was to determine whether the cream base could be prepared using the different concentration of the ingredients listed previously. The cream bases were placed in wide mouth ointment jars which were filled completely and were stored at 25±2° for one month. The ointments were then visually evaluated according to the results of Table 4-1.

3.3. Second Screening Evaluation

After First screening evaluation seventy one selected cream bases were subjected to second screening evaluation.

The pH of a cream base is very important as it decides whether the cream is acidic or alkaline. If the pH of the cream is adjusted on the alkaline side, the stratum corneum will assume a more hydrophilic character. Keratin is an amphoteric protein with an isoelectric point at pH approximately 5 which imparts a pH between 5 to 6 to the skin itself[1,2].

However, the pH of the base may also be of importance for the stability of drug as well as its absorption specially in these days with number of drugs available. For topical therapy, this aspect has gained more importance during the past few years. In order to exert their therapeutic effect, the drugs are required to be released and absorbed by the skin. The pH of the prepared bases was therefore determined by preparing a 1:2 or 1:10 dilution or dispersion of these bases in distilled water.

The pH of the cream base was determined using a LI-15 (Elico) Model pH meter. The pH values obtained initially and after one month storage at different conditions for the various bases under study are recorded in Table 4-2.

These cream bases were simultaneously studied for spreadability and water washability. These cream bases were stored at 25±3° for one month and then they were visually evaluated for spreadability and washability[3]. Spreadability was studied by spreading each base on the back of the hand and on a glass slab. Results were simply reported as "positive", if the cream base spreads

TABLE 4-2:

Second Screening Evaluation of Cream Bases.

Base Nos.	Initial	pH at				Spread-ability	Water Washability
		Cold stor-age.	R.T.	37° 80%RH	42° 80%RH		
II	7.8	7.8	7.8	7.9	8.0	(+)	E.W.
III	7.1	7.3	7.25	7.3	7.3	(+)	E.W.
IV	6.8	6.7	6.8	6.8	6.8	(-)	E.W.
V	6.5	6.5	6.5	6.6	6.6	(+)	E.W.
VI	5.8	5.9	5.8	5.8	5.8	(+)	E.W.
VII	5.6	5.7	5.7	5.7	5.7	(+)	N.W.
IX	5.0	5.2	5.2	5.3	5.3	(-)	W.S.D.
X	7.5	7.6	7.6	7.5	7.5	(+)	E.W.
XII	6.4	6.4	6.5	6.5	6.5	(+)	E.W.
XVI	7.8	7.9	8.0	7.9	8.0	(+)	E.W.
XVII	8.5	8.6	8.6	8.5	8.6	(+)	E.W.
XXI	7.2	7.2	7.2	7.2	7.2	(+)	E.W.
XXII	5.9	6.0	6.0	6.0	6.0	(+)	E.W.
XXIII	8.7	8.8	8.8	9.0	9.0	(+)	E.W.
XXVI	8.25	8.4	8.4	8.5	8.5	(+)	E.W.
XXIX	8.35	8.5	8.5	8.5	8.5	(+)	E.W.
XXX	5.6	5.8	5.8	5.8	5.9	(+)	E.W.
XXXI	6.8	6.9	6.9	6.9	6.8	(+)	N.W.

Key : (+) - Positive.

(-) - Negative.

N.W.: Non Washable

E.W.: Easily Washable

W.S.D.: Washable with slight difficulty

TABLE 4-2:

Second Screening Evaluation of Cream Bases.

Base Nos.	Initial	pH at				Spreadability	Water Washability
		Cold storage.	R.T.	37° 80%RH	42° 80%RH		
XXXII	5.8	5.9	5.8	5.8	5.8	(+)	E.W.
XXXIII	5.7	5.7	5.7	5.7	5.7	(+)	E.W.
XXXVII	6.4	6.3	6.3	6.3	6.8	(-)	E.W.
XXXVIII	6.1	6.1	6.0	6.1	6.1	(+)	E.W.
XLVI	5.85	5.8	6.0	6.0	6.0	(+)	E.W.
XLVII	6.1	6.2	6.3	6.3	6.3	(+)	E.W.
XLVIII	6.0	6.1	6.2	6.1	6.1	(+)	E.W.
IL	6.5	6.4	6.3	6.3	6.3	(+)	E.W.
L	7.1	7.3	7.3	7.2	7.2	(+)	E.W.
LIII	5.4	5.6	5.6	5.8	5.8	(+)	E.W.
LIV	6.5	6.7	6.8	6.8	6.8	(+)	E.W.
LVII	6.4	6.4	6.4	6.4	6.4	(+)	E.W.
LVIII	6.7	6.8	6.8	6.8	6.8	(+)	E.W.
LIX	6.5	6.5	6.5	6.5	6.5	(+)	E.W.
LX	5.7	5.8	5.8	5.8	5.8	(+)	E.W.
LXI	7.6	7.6	7.6	7.6	7.6	(+)	E.W.
LXII	5.2	5.2	5.2	5.2	5.2	(+)	E.W.
LXIII	6.4	6.4	6.4	6.4	6.4	(+)	E.W.
LXIV	5.8	5.8	5.8	5.8	5.8	(+)	E.W.
LXV	6.6	6.6	6.6	6.7	6.7	(+)	E.W.
LXVI	5.55	5.6	5.6	5.6	5.6	(-)	E.W.

TABLE 4-2:

Second Screening Evaluation of Cream Bases.

Base Nos.	Initial	pH at Cold storage.	pH at R.T.	pH at 37° 80%RH	pH at 42 80%RH	Spreadability	Water Washability
LXVII	8.2	8.2	8.2	8.1	8.0	(+)	E.W.
LXVIII	6.7	6.7	6.7	6.7	6.8	(+)	E.W.
LXIX	6.4	6.4	6.4	6.4	6.4	(+)	E.W.
LXX	7.8	7.8	7.9	7.9	7.9	(+)	E.W.
LXXI	7.2	7.2	7.2	7.2	7.2	(+)	E.W.
LXXII	6.8	6.8	6.9	6.9	6.8	(+)	E.W.
LXXIII	7.2	7.2	7.3	7.4	7.4	(+)	E.W.
LXXIV	5.9	5.9	6.2	6.2	6.2	(+)	E.W.
LXXV	6.3	6.3	6.3	6.3	6.3	(+)	E.W.
LXXVI	6.1	6.1	6.1	6.0	6.0	(+)	E.W.
LXXVII	5.5	5.5	5.5	5.5	5.5	(-)	E.W.
LXXVIII	5.4	5.4	5.5	5.4	5.4	(-)	E.W.
LXXIX	7.6	7.6	7.6	7.6	7.6	(+)	E.W.
LXXXI	7.2	7.2	7.4	7.4	7.4	(+)	E.W.
LXXXVI	6.2	6.2	6.3	6.3	6.3	(+)	E.W.
IXC	6.8	6.8	6.9	6.9	6.9	(+)	E.W.
XC	5.6	5.6	5.6	5.6	5.6	(-)	E.W.
XCIII	6.6	6.6	6.6	6.6	6.6	(+)	E.W.
XCIV	7.1	7.1	7.0	7.0	7.0	(-)	E.W.
XCV	7.0	7.0	7.0	7.0	7.0	(+)	E.W.
IC	7.2	7.2	7.3	7.3	7.3	(+)	E.W.
C	7.35	7.4	7.4	7.5	7.5	(+)	E.W.
CI	5.8	5.8	5.8	5.6	5.6	(-)	E.W.
CII	7.1	7.1	7.1	7.1	7.1	(+)	E.W.
CIII	6.6	6.7	6.7	6.8	6.8	(+)	E.W.
CIV	7.2	7.2	7.2	7.2	7.2	(+)	E.W.
CV	7.5	7.6	7.6	7.6	7.6	(+)	E.W.
CVI	6.9	7.0	7.0	7.0	7.0	(+)	E.W.
CVII	7.25	7.3	7.3	7.3	7.3	(+)	E.W.
CVIII	7.6	7.8	7.8	7.8	7.8	(+)	E.W.
CIX	7.9	8.0	8.0	8.1	8.1	(+)	E.W.

easily forming an even layer on the skin and "Negative" if the cream base resists even spreading or rolls up and does not form an even layer.

Water washability was studied by spreading the cream bases by one hand on the back of the other hand. The hand with cream bases were placed under running water from tap and water was allowed to run over it for thirty seconds. At the same time if required, hand was gently rubbed with the first finger. The results of the washability were reported simply as non washable, easily washable, washable with slight difficulty. The results are recorded in Table 4-2.

3.4. Third Screening Evaluation

So far, physical characterestics such as consistancy, slip, spreadability and feel of ointments and creams have been expressed rather vaguely. Until recently, the evaluation of these properties had only involved personal judgement of the workers and consequently no positive standards of values could be set for them. On the other hand, no other class of pharmaceutical products has been subjected to so close and critical observation by consumers in the course of their use than are ointments, creams, pastes and gels.

The pharmaceutical elegance of all topical semisolids is most directly related to consistancy, shear, appearance and touch.

After second screening evaluation sixty selected cream bases were subjected to third screening evaluation. Tightly closed jars, having cream bases were stored in an oven at 37 ± 1° at 80% RH, 42° ± 1° at 80% RH, in a refrigerator, at 5 ± 2°, and at room temperature at 25 ± 3° for one month, subjected to consistancy study and compared with initial results.

3.4.a. Consistancy study

The penetrometer has been reported to successfully measure cream base consistancy[4]. Singiser and Beal[5] tool for measuring the consistancy of cream base sample with penetration reading less than four hundred. This method was the same as the USP method for determining the consistancy of petrolatum. Penetration is defined as the consistancy of a material expressed as the distance that a standard cone or needle penetrates a sample under known conditions of loading, time and temperature.

At the end of the storage period, the consistancy of the cream bases which were stored in the oven and in the refrigerator was compared to the respective samples (cream bases) stored at room temperature. Penetration tests were carried out at 25 ± 2° for 5 sec. The container sizes were as follows.

Stainless steel bowl of external diameter 58 mm, internal diameter of 54 mm and depth of 43 mm was used. Total weight of the plunger with cone and other extra weight (50 g) was 152 g (102 g + 50 g). The cream bases were first filled in above S.S. Bowl to a top with tapping, then allowed to remain as such for 24 hours at 25°±2°. Next day the excess of cream bases were scraped of by spatula. The measurement was made by placing a jar in position with the apex of the cone resting on the surface of the sample. The plunger was released for five seconds and the cone allowed to penetrate into the samples. The penetration, in tenths of a millimeter, was read off on the indicator scale. For each measurement zero reading was set to reduce error. Initial readings and average of two readings are recorded in Table 4-3.

3.4.b. <u>Penetration study</u>

For assessing the penetration very simple experiments have been suggested. About 500 mg of cream bases were taken and rubbed over 4 cm^2 area of the forearm skin in circular motion for a minute. The selection of cream bases was based on the following desirable characteristics.

1. <u>Good</u> : No white smear and visually all cream base penetrated.
2. <u>Poor</u> : White smear observed and visually some amount of cream base remained after one minute of rubbing.

3.4.c. Spreadability

For the skin therapy the vehicle used should be aesthetically satisfactory. To a considerable extent the utility and the acceptability of an ointment base depends on consistancy. Nevertheless, it is often difficult to explain exactly all the properties covered by the term 'consistancy'. The cream is expected to spread easily on the skin from the point of view of patient, as this facter ensures the acceptance of the product. This is because, if a cream spreads easily without the need for much pressure, its application to painful areas will be much more comfortable. This is particularly true when it is necessary to rub or apply the ointment on a wound from the point of view of pharmacist. An ointment or a cream showing high resistance to spreading is a poor levigating agent because much of work input is lost in overcoming the resistance of the base. To spread well, an ointment or a cream should behave like a good lubricant exhibiting maximum slip and minimum drag. On this basis, a force required to pull one surface over another surface, both being separated only by a thin layer of the ointment, appears to be a reasonable method for measuring spreadability. This is the basis of the method suggested by Mutimer *et al*.[6]. Henderson *et al*.[7] reported the spreadability of the ointment may vary from 10^2 to 10^5 sec. Their work indicated that it is possible to device a master curve of the rheological conditions which operate with products applied topically. Hence Barry[8] used Ferranti-Shirley Viscometer to determine shearing stress produced in ointments at various shear rates with the medium and cone maintained at skin temperature, 34±1°. In another method Barry and Meyer[9] prepared a master curve from rheological data obtained using sensory test with a panel of 24 male subjects.

Though all these methods have been proposed, the method suggested by Mutimar et al.[6] has been found to be simple and most practical. However, no specific dimensions for the plate as well as distance required to be travelled by the upper plate have been mentioned. Hence based on these principles, a simple device for testing of spreadability was designed in the laboratory.

Spreadability testing unit

Two glass plates 20 cm x 50 cm in size were selected and one of these was fixed permanently on a wooden block with the help of an adhesive. To the other plate a knob was fixed at one end and a string was tied to the knob which was allowed to go over a pulley fixed at a distance of 10.5" on the wooden block. To the other end of the string a pan was fixed for addition of weights, in order to move the upper plate. The upper plate and the height of the pully were levelled and were kept at the same level. This unit was placed on a table having 2.5 feet height.

TABLE 4-4 : Spreading Properties of Cream Bases

Serial Nos. of Cream bases	Assigned Nos. of Cream bases	Spreading time (Sec.)
II	28	37
X	29	70
XVI	30	63
XVII	31	46
XXIII	18	38
XXVI	17	65
XXIX	14	61
XXX	21	53
XLVII	32	36
XLVIII	20	40
IL	12	43
L	13	30
LXIII	1	28
LXIV	2	40
LXV	3	33
LXVII	33	65
LXVIII	4	37
LXIX	5	46
LXX	34	59
LXXI	6	51
LXXII	7	32
LXXIII	8	30
LXXIV	9	34
LXXV	10	60
LXXVI	11	35
LXXXVI	16	50
IXC	22	40
XCIII	19	45
CII	25	41
CIII	27	38
CIV	15	46
CVII	24	44
CVIII	26	56
CIX	23	45

Test Procedure

An excess of cream under study was placed in between the two plates and one kg weight was placed over the upper plate for five minutes to allow the air to escape. Excess of cream coming out from the sides was scrapped off. The top plate was then subjected to a pull by adding weights to the pan totalling to 80 g. The time required for the upper plate to move a fixed distance of exactly 10 cm was noted with the help of a stop-watch, which was used as a measure of spreadability. Naturally lesser the time required to move the distance of 10 cm by the upper plate, better was the spreadability of the base.

After third screening evaluation thirty four selected cream bases were subjected to spreadability testing by above method and the results are recorded in Table 4-4.

3.5 Rheology of Bases

Important considerations in the formulation of semisolid preparations are consistancy and physical stability. The former is always described with qualitative adjectives but no quantitative measure is available to give the correct idea about the consistancy by one determination. However, their flow behaviour during manufacture, filling with machine for packing as well as removal from collapsible tube is dependent on consistancy. Since the consistancy cannot be measured by viscosity alone, the flow behaviour ie. rheograms which significantly differentiate between various semisolid preparations, are required to be determined. At the same time it is expected that the dosage form should remain unaffected during the storage in terms of its physical stability, and the incorporated drug should also remain stable without deterioration. Although the latter can be assessed by chemical or microbiological assay procedures, the former is required to be judged by other means. In the formation of semisolid preparations, rheological behaviour under different stresses serve as a means for assessing this physical stability.

The consistancy of a non-Newtonian system is attributed to the summation of many complex properties such as flow behaviour, stickyness and the spreading ability. All these properties cannot be expressed adequately by a single parameter, however, the fundamental rheological behaviour which is indicative of consistancy can be determined by utilising simple devices such as different rotational type viscometers. Moreover an inspection of the complete rheogram of shearing stress versus rate of shear on the cream basis.

The principle deterrent in the rheological studies of semisolids has been the lack of a suitable instrument. Any instrument which is to be successfully employed in the rheological analysis must be adaptable to operation at several rates of shear and must be so constructed that a mechanical analysis of the data obtained would be possible. A survey of literature indicated that an instrument which would best satisfy these conditions would be a properly designed rotational viscometer.

Hamill and Petersen[10] studied the effect of aging and surfactant concentration on the rheology and droplet size distribution of a non-aqueous emulsion. They also studied the effect of surfactant concentration on the interfacial viscosity of a nonaqueous system.

Ooteghem[11] studied the rheological analysis of the compounding and use of ointments. Kedvessy and Eros[12] studied the influence of technological treatment on the rheological property (quality) of various ointment bases. The regeneration of structure took place slowly and was not complete.

Barry and Grace[13] worked on the investigation of semisolid lipophilic preparations by small strain and continuous shear viscometry and their application to texture profile.

Barry and Sauders[14] studied the variation of rheology of systems containing cetrimide, Cetostearyl alcohol with temperature.

A review of the various methods of rheology and rheology of different types of ointments have been carried out by a number of workers.[15-18]

Barry[19] studied the continuous shear, viscoelastic and spreading properties of a new topical vehicle, FAPG base.

Sensory testing of spreadability and investigation of rheological conditions operative during application of topical preparations, were done once again by Barry and Grace.[20]

The rheological properties of starch glycerol were investigated by Madsen and Jensen[21]. The rheological properties of the glycerin of starch containing 5,7 and 9% wheat starch respectively and brought to gelatinised by heating it in an autoclave at 120° for various periods of time were investigated using a parallel plate viscometer and flow curves obtained by a Brookfield Syncro-Lectic Viscometer. The heat distribution in the ointment during autoclaving was also examined.

Davis et al.[22] stated that the very versatility of the instrument can lead to problem. In automatic mode, different combinations of sweep times and maximum shear rates alter the rheogram shape and interlaboratory comparisons may be difficult.

Boylan[18] observed the slip of material at the cone or plate surface. To minimise these errors, one should use long sweep times, particularly with the larger cones.

A common source of trouble in cone-plate viscometry is that the instrument may eject material from the gap. For example, some batches of soft paraffin provide very irregular rheograms when tested in automatic mode. The viscometer almost completely expels the sample from the gap after the spur point so that the measured torque falls to almost zero.[23]

McKennell[24] observed the increase in temperature at extreme shear rates because of viscous heating.

Davis et al.[22] observed the serious artifacts in the rheogram due to the evaporation at the free surface of the material, even when he used an antievaporation unit.

3.5.a. Rheological measurements

Selected cream bases were analysed for their rheological behaviour by Rheotest-2 machine using the thermostatic vessel to maintain the temperature 30±2° during the measurements. About 30 g of the preparation was used for each flow curve using H/H system.

The flow curves were drawn and analysed for the desired data, like area of the thixotropic loop, apparent viscosity at the top of graph, yield value, etc. and are computed in Table 4-33. The measurements were repeated twice and average values were taken after one month storage at R.T.

The thixotropic index is generally taken as the area circumscribed by the hysteresis loop of the rheogram.

By indicating the shearing stress, τR, as the intercept of the down curve with abscissa, the location in the diagram is determined. This value indicates the degree to which the internal structure of the system has

TABLE 4-5:

Continuous Shear Rheometry Data of Cream Base No. 1.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	118.6	69.18
2b	0.9	207.55	88.95
1a	1.0	237.2	88.95
3b	1.5	311.32	118.60
2a	1.8	335.8	177.90
4b	2.7	459.6	237.20
3a	3.0	474.4	266.85
5b	4.5	548.52	365.67
4a	5.4	632.53	444.75
6b	8.1	761.00	553.47
5a	9.0	830.20	612.77
7b	13.5	1008.10	761.01
6a	16.2	1097.05	879.60
8b	24.3	1334.25	1008.10
7a	27	1393.55	1057.01
9b	40.50	1670.28	1284.75
8a	48.6	1788.90	1403.43
10b	72.9	2065.38	1719.70
9a	81.0	2184.42	1848.01
11b	121.5	2609.20	2213.86
10a	145.8	2796.98	2391.76
12b	218.7	3182.43	2885.93
11a	243.0	3350.45	3163.83
12a	437.4	4030.03	

Key : U.C. = Upcurve

D.C. = Down curve

TABLE 4-6:

Continuous Shear Rheometry Data of Cream Base No. 2.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	489.225	311.325
2b	0.9	653.3	504.05
1a	1.0	711.6	548.525
3b	1.5	874.67	638.475
2a	1.8	1022.92	696.775
4b	2.7	1363.9	948.8
3a	3.0	1452.85	1022.925
5b	4.5	1660.4	1260.125
4a	5.4	2001.52	1526.975
6b	8.1	2520.25	1867.95
5a	9.0	2609.2	1957.05
7b	13.5	2890.875	2431.3
6a	16.2	3409.75	2609.2
8b	24.3	4180.5	3394.9
7a	27	4314.07	3756.725
9b	40.50	4862.6	4566.1
8a	48.6	5248.05	4966.15
10b	72.9	5870.7	

TABLE 4-7:

Continuous Shear Rheometry Data of Cream Base No. 3.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	177.9	118.6
2b	0.9	237.2	177.9
1a	1.0	281.625	207.55
3b	1.5	326.15	237.2
2a	1.8	385.45	266.85
4b	2.7	474.4	296.5
3a	3.0	504.05	400.275
5b	4.5	593	444.75
4a	5.4	711.6	474.4
6b	8.1	770.9	504
5a	9.0	1067.4	533.7
7b	13.5	1408.35	770.9
6a	16.2	1601.1	830.2
8b	24.3	2016.2	1156.35
7a	27	2134.8	1245.3
9b	40.50	2372	1660.4
8a	48.6	2475.775	1719
10b	72.9	2787.1	2105.15
9a	81.0	2846.4	2253.4
11b	121.5	3057.1	

TABLE 4-8:

Continuous Shear Rheometry Data of Cream Base No. 4.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	222.375	88.95
2b	0.9	266.85	118.6
1a	1.0	296.5	207.55
3b	1.5	415.1	296.5
2a	1.8	459.575	355.8
4b	2.7	622.65	489.225
3a	3.0	652.3	533.7
5b	4.5	800.85	667.625
4a	5.4	874.67	770.9
6b	8.1	1097.05	874.675
5a	9.0	1126.7	948.5
7b	13.5	1186	

TABLE 4-9:

Continuous Shear Rheometry Data of Cream Base No. 5.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	533.7	415.1
2b	0.9	756.07	533.7
1a	1.0	830.2	578.175
3b	1.5	869.5	667.125
2a	1.8	1022.92	770.9
4b	2.7	1274.95	1008.1
3a	3.0	1467.675	1067.4
5b	4.5	1956.9	1362.9
4a	5.4	2253.4	1660.4
6b	8.1	2979.83	1942.07
5a	9.0	3113.25	2490.6
7b	13.5	3795.2	2787.1
6a	16.2	3973.1	3498
8b	24.3	4788.475	4165.825
7a	27	4862.6	4477.15
9b	40.50	5514.9	

TABLE 4-10 : Continuous Shear Rheometry Data of Cream Base No. 6.

Speed	Shear rate r.p.m.	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	192.725	118.6
2b	0.9	252.025	148.25
1a	1.0	281.675	177.9
3b	1.5	355.8	237.2
2a	1.8	459.6	266.85
4b	2.7	489.225	296.5
3a	3.0	533.7	415.1
5b	4.5	669.125	444.75
4a	5.4	696.775	459.575
6b	8.1	785.025	474.4
5a	9.0	830.2	533.7
7b	13.5	1008.1	607.825
6a	16.2	1037.75	622.65
8b	24.3	1141.425	711.6
7a	27	1186	721.483
9b	40.50	1289.779	889.5
8a	48.6	1334.25	933.975
10b	72.9	1526.975	1008.1
9a	81.0	1571.45	1067.4
11b	121.5	1692.4	1186
10a	145.8	1894.4	1334.25
12b	218.7	2075.5	1779
11a	243.0	2194.1	1867.95
12a	437.4	2357.175	

TABLE 4-11:

Continuous Shear Rheometry Data of Cream Base No. 7.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	177.9	118.6
2b	0.9	237.2	148.45
1a	1.0	296.5	207.55
3b	1.5	415.1	296.5
2a	1.8	474.4	355.45
4b	2.7	681.95	533.7
3a	3.0	711.6	593
5b	4.5	933.98	741.25
4a	5.4	1067.4	830.2
6b	8.1	1245.3	1008.1
5a	9.0	1304.6	1141.53
7b	13.5	1541.8	1289.779
6a	16.2	1660.4	1467.675
8b	24.3	2060.67	1764.179
7a	27	2223.55	1867.95
9b	40.50	2994.65	2105.19
8a	48.6	3172.55	2312.7
10b	72.9	3364.62	2668.5
9a	81.0	3587.59	3024.3
11b	121.5	4062.05	3424.575
10a	145.8	4328.9	3765.55
12b	218.7	5040.5	4684.7
11a	243.0	5307.35	

TABLE 4-12:

Continuous Shear Rheometry Data of Cream Base No. 8.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	168.016	118.6
2b	0.9	257.0667	148.25
1a	1.0	306.383	177.9
3b	1.5	365.683	237.2
2a	1.8	405.217	266.55
4b	2.7	523.817	296.5
3a	3.0	583.117	415.1
5b	4.5	691.833	474.4
4a	5.4	721.483	474.4
6b	8.1	780.883	533.7
5a	9.0	820.416	563.35
7b	13.5	899.283	622.65
6a	16.2	968.367	652.3
8b	24.3	1008.1	741.25
7a	27	1086.933	859.85
9b	40.50	1116.816	919
8a	48.6	1156.35	978.3
10b	72.9	1255.183	1052.45
9a	81.0	1304.6	1141.525
11b	121.5	1492.383	1319.425
10a	145.8	1620.866	1452.85
12b	218.7	1887.715	1660.4
11a	243.0	2016.2	1779
12a	437.4	2640.90	

TABLE 4-13 : Continuous Shear Rheometry Data of Cream Base No. 9.

Speed	Shear rate r.p.m.	Average of shear stress U. C. dynes/cm^2	Average of shear stress D. C. dynes/cm^2
1b	0.5	174.6	118.6
2b	0.9	252.025	177.9
1a	1.0	281.675	207.55
3b	1.5	326.15	252.025
2a	1.8	385.45	266.85
4b	2.7	474.4	296.5
3a	3.0	504.05	402.25
5b	4.5	593	450.75
4a	5.4	712.6	480.2
6b	8.1	970.9	499.75
5a	9.0	1067.4	849.55
7b	13.5	1408.35	919.15
6a	16.2	1690.05	963.625
8b	24.3	2105.15	1120
7a	27	3134.8	1186
9b	40.50	2520.25	1660.4
8a	48.6	2640.9	1779
10b	72.9	2979.83	2312.7
9a	81.0	3024.3	2520.25
11b	121.5	3320.8	

TABLE 4-14:

Continuous Shear Rheometry Data of Cream Base No. 10.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	276.733	237.2
2b	0.9	365.683	296.5
1a	1.0	454.633	355.8
3b	1.5	513.933	415.1
2a	1.8	573.233	474.4
4b	2.7	721.483	593
3a	3.0	751.133	652.3
5b	4.5	889.5	770.9
4a	5.4	988.333	889.5
6b	8.1	1245.3	1082.225
5a	9.0	1344.133	1186
7b	13.5	1749.35	1482.5
6a	16.2	1925.116	1660.4
8b	24.3	2233.633	1894.4
7a	27	2312.7	1956.9
9b	40.50	2717.916	2194.1
8a	48.6	3083.6	2312.7
10b	72.9	3241.733	2609.2
9a	81.0	3370.216	2727.8
11b	121.5	3755.666	3142.9
10a	145.8	3973.1	3320.8
12b	218.7	4289.366	3554.5
11a	243.0	4398.08	4032.4
12a	437.4	5020.733	

TABLE 4-15:

Continuous Shear Rheometry Data of Cream Base No. 11.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	237.2	118.6
2b	0.9	296.5	148.25
1a	1.0	326.15	192.875
3b	1.5	355.8	237.2
2a	1.8	415.1	296.5
4b	2.7	474.4	355.8
3a	3.0	533.7	415.1
5b	4.5	593	474.4
4a	5.4	652.3	533.7
6b	8.1	756.075	652.3
5a	9.0	830.2	696.775
7b	13.5	1008.1	830.2
6a	16.2	1126.7	919.15
8b	24.3	1408.375	1067.4
7a	27	1482.5	1141.525
9b	40.50	2016.2	1304.6
8a	48.6	2253.4	1423.2
10b	72.9	2372	1645.575
9a	81.0	2505.425	1779
11b	121.5	2549.9	2253.4
10a	145.8	2668.5	2490
12b	218.7	3053.9	

TABLE 4-16:

Continuous Shear Rheometry Data of Cream Base No. 12.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	578.175	355.8
2b	0.9	652.3	415.1
1a	1.0	711.6	548.525
3b	1.5	830.2	548.525
2a	1.8	948.8	593
4b	2.7	1186	726.425
3a	3.0	1200.825	770.9
5b	4.5	1334.25	948.8
4a	5.4	1452.85	1037.75
6b	8.1	1690.05	1274.95
5a	9.0	1764.175	1334.25
7b	13.5	2105.15	1630.75
6a	16.2	2238.625	1749.35
8b	24.3	2460.95	1956.9
7a	27	2520.25	2105.15
9b	40.50	2846.4	2253.4
8a	48.6	2965	2431.3
10b	72.9	3231.85	2787.1
9a	81.0	3320.8	2876.5
11b	121.5	3735.9	3320.8
10a	145.8	3943.45	3528.05
12b	218.7	4417.85	4091.7
11a	243.0	4506.8	4358.55
12a	437.4	5633.5	

TABLE 4-17:

Continuous Shear Rhedmetry Data of Cream Base No. 13.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	474.4	296.5
2b	0.9	622.65	355.8
1a	1.0	652.3	415.1
3b	1.5	711.6	444.75
2a	1.8	830.2	533.7
4b	2.7	948.5	593
3a	3.0	1008.1	652.3
5b	4.5	1186	830.2
4a	5.4	1304.6	948.8
6b	8.1	1526.975	1126.7
5a	9.0	1541.8	1186
7b	13.5	1719.7	1363.9
6a	16.2	1838.3	1482.5
8b	24.3	1894.4	1660.4
7a	27	1956.9	1719.7
9b	40.50	2134.8	1894.4
8a	48.6	2288.575	2016.2
10b	72.9	2490.6	2194.1
9a	81.0	2609.2	2312.7
11b	121.5	2965	2668.5
10a	145.8	3202.2	2846.5
12b	218.7	3617.3	3261.5
11a	243.0	3676.6	3409.7
12a	437.4	4358.55	

TABLE 4-18:

Continuous Shear Rheometry Data of Cream Base No. 14.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	474.4	237.2
2b	0.9	593	355.8
1a	1.0	652.3	474.4
3b	1.5	711.6	533.7
2a	1.8	770.9	593
4b	2.7	933.975	696.775
3a	3.0	1008.1	741.25
5b	4.5	1126.7	815.275
4a	5.4	1260.129	933.975
6b	8.1	1438.025	1111.775
5a	9.0	1482.5	1141.425
7b	13.5	1571.85	1200.725
6a	16.2	1601.1	1319.475
8b	24.3	1764.175	1408.525
7a	27	1808.65	1452.85
9b	40.50	1956.9	1601.1
8a	48.6	2075.5	1704.875
10b	72.9	2268.45	1880.775
9a	81.0	2283.5	2016.2
11b	121.5	2535.075	2238.575
10a	145.8	2683.325	2401.65
12b	218.7	3113.25	2757.45
11a	243.0	3261.5	3009.475
12a	437.4	3854.5	

TABLE 4-19:

Continuous Shear Rheometry Data of Cream Base No. 15.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	355.8	192.725
2b	0.9	444.75	222.375
1a	1.0	504.05	237.2
3b	1.5	593.00	252.025
2a	1.8	669.125	296.5
4b	2.7	845.025	355.8
3a	3.0	904.325	385.45
5b	4.5	1112.1	474.4
4a	5.4	1393.85	563.35
6b	8.1	1630.75	593
5a	9.0	1749.35	669.125
7b	13.5	2031.025	874.675
6a	16.2	2149.625	1022.925
8b	24.3	2283.05	1319.475
7a	27	2341.35	1349.075
9b	40.50	2579.55	1571.45
8a	48.6	2742.625	1749.35
10b	72.9	3113.25	1986.55
9a	81.0	3261.5	2105.15
11b	121.5	3646.95	2490.6
10a	145.8	3750.725	2668.5
12b	218.7	3943.49	3068.765
11a	243.0	4017.575	3291.15
12a	437.4	4329.00	

TABLE 4-20:

Continuous Shear Rheometry Data of Cream Base No. 16.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	355.8	118.6
2b	0.9	474.4	222.375
1a	1.0	504.05	370.625
3b	1.5	578.175	489.225
2a	1.8	637.475	533.7
4b	2.7	815.375	563.35
3a	3.0	889.5	637.475
5b	4.5	1067.4	711.6
4a	5.4	1186	815.525
6b	8.1	1438.025	934.175
5a	9.0	1304.2	993.45
7b	13.5	1408.375	1156.35
6a	16.2	1526.975	1245.3
8b	24.3	1749.35	1393.55
7a	27	1823.575	1482.5
9b	40.50	2164.45	1719.7
8a	48.6	2283.05	1823.75
10b	72.9	2535.075	1956.9
9a	81.0	2609.2	2045.85
11b	121.5	2965	2372.00
10a	145.8	3142.9	2505.425
12b	218.7	3632.125	2816.75
11a	243.0	3898.975	2935.35
12a	437.4	4151	

TABLE 4-21:

Continuous Shear Rheometry Data of Cream Base No. 17.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	504.05	177.9
2b	0.9	622.1	207.55
1a	1.0	666.595	429.925
3b	1.5	785.725	503.5
2a	1.8	861.350	578.175
4b	2.7	1037.750	652.3
3a	3.0	1008.1	741.25
5b	4.5	1215.65	874.675
4a	5.4	1304.6	978.45
6b	8.1	1601.1	1215.65
5a	9.0	1734.55	1304.6
7b	13.5	1897.6	1541.8
6a	16.2	1986.55	1719.7
8b	24.3	2283.05	2075.5
7a	27	2372.0	2164.45
9b	40.50	2638.85	2431.3
8a	48.6	2816.75	2638.85
10b	72.9	3291.15	2994.65
9a	81.0	3454.225	3113.25
11b	121.5	4002.75	3558
10a	145.8	4239.95	3735.9
12b	218.7	4551.45	4121.35
11a	243.0	4595.75	4447.5
12a	437.4	5425.95	

TABLE 4-22:

Continuous Shear Rheometry Data of Cream Base No. 18.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	340.975	103.775
2b	0.9	385.45	118.6
1a	1.0	415.1	118.6
3b	1.5	474.4	118.6
2a	1.8	504.05	148.25
4b	2.7	533.7	177.9
3a	3.0	563.35	207.55
5b	4.5	622.65	237.2
4a	5.4	711.6	266.85
6b	8.1	904.325	429.925
5a	9.0	993.275	548.525
7b	13.5	1141.525	578.175
6a	16.2	1245.3	652.3
8b	24.3	1497.325	933.975
7a	27	1556.625	1022.925
9b	40.50	1942.075	1319.425
8a	48.6	2031.025	1497.325
10b	72.9	2327.525	1912.425
9a	81.0	2490.6	1927.25
11b	121.5	2876.05	2283.05
10a	145.8	3142.9	2520.25
12b	218.7	3587.65	3009.475
11a	243.0	3750.725	3187.375
12a	437.4	4655.05	

TABLE 4-23:

Continuous Shear Rheometry Data of Cream Base No. 19.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	192.725	103.775
2b	0.9	355.8	103.775
1a	1.0	385.45	118.6
3b	1.5	459.575	118.6
2a	1.8	533.7	118.6
4b	2.7	667.125	148.25
3a	3.0	741.25	177.9
5b	4.5	889.5	177.9
4a	5.4	1008.1	207.55
6b	8.1	1245.3	207.55
5a	9.0	1274.95	237.2
7b	13.5	1438.025	252.025
6a	16.2	1482.5	252.025
8b	24.3	1779	281.675
7a	27	1793.825	340.975
9b	40.50	2016.2	474.4
8a	48.6	2105.15	563.35
10b	72.9	2297.875	815.375
9a	81.0	2253.4	978.45
11b	121.5	2312.7	1245.3
10a	145.8	2372	1393.6
12b	218.7	2490.6	1838.3
11a	243.0	2609.2	2075.5
12a	437.4	3024.3	

TABLE 4-24:

Continuous Shear Rheometry Data of Cream Base No. 20.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	385.45	237.2
2b	0.9	504.05	237.2
1a	1.0	563.35	237.2
3b	1.5	696.775	296.5
2a	1.8	770.9	355.8
4b	2.7	948.8	474.4
3a	3.0	1008.1	533.7
5b	4.5	1304.6	667.125
4a	5.4	1482.5	770.9
6b	8.1	2016.2	1008.1
5a	9.0	2105.15	1067.4
7b	13.5	2549.9	1304.6
6a	16.2	2727.8	1482.5
8b	24.3	3202.2	1853.125
7a	27	3350.45	1986.55
9b	40.50	3676.6	2372
8a	48.6	3913.8	2668.5
10b	72.9	4239.35	3024.3
9a	81.0	4584.7	3558
11b	121.5	4951.55	4506.8
10a	145.8	5099.8	

TABLE 4-25:

Continuous Shear Rheometry Data of Cream Base No. 21.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	355.8	296.5
2b	0.9	474.4	400.275
1a	1.0	504.05	444.75
3b	1.5	593	518.875
2a	1.8	652.3	622.65
4b	2.7	785.875	669.775
3a	3.0	845.025	698.775
5b	4.5	1037.75	845.025
4a	5.4	1186	904.325
6b	8.1	1393.55	1052.575
5a	9.0	1452.85	1141.525
7b	13.5	1690.05	1304.6
6a	16.2	1838.3	1423.2
8b	24.3	2134.8	1573.45
7a	27	2253.4	1630.75
9b	40.50	2668.5	1764.175
8a	48.6	2742.625	1808.65
10b	72.9	3024.3	2060.675
9a	81.0	2965	2105.15
11b	121.5	3113.25	2416.48
10a	145.8	3187.375	2609.35
12b	218.7	3528.1	2935.35
11a	243.0	3691.425	3039.1
12a	437.4	3973.1	

TABLE 4-26:

Continuous Shear Rheometry Data of Cream Base No. 22.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	296.5	103.775
2b	0.9	385.45	133.425
1a	1.0	415.1	118.6
3b	1.5	504.05	118.6
2a	1.8	533.7	133.425
4b	2.7	726.425	179.9
3a	3.0	741.25	133.425
5b	4.5	948.8	179.9
4a	5.4	1082.45	177.9
6b	8.1	1452.85	207.55
5a	9.0	1482.5	237.2
7b	13.5	1577.775	252.025
6a	16.2	1690.05	296.5
8b	24.3	1956.9	355.8
7a	27	1986.55	385.45
9b	40.50	2119.975	489.225
8a	48.6	2134.8	548.525
10b	72.9	2431.3	726.425
9a	81.0	2520.25	785.725
11b	121.5	2727.8	1052.8
10a	145.8	2890.875	1215.65
12b	218.7	3172.55	1734.525
11a	243.0	3261.5	1956.9
12a	437.4	3439.4	

TABLE 4-27:

Continuous Shear Rheometry Data of Cream Base No. 23.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	340.975	118.6
2b	0.9	355.8	118.6
1a	1.0	370.625	148.25
3b	1.5	385.45	177.9
2a	1.8	415.1	177.9
4b	2.7	533.7	281.675
3a	3.0	563.35	340.975
5b	4.5	830.2	489.225
4a	5.4	948.8	637.475
6b	8.1	1156.35	889.5
5a	9.0	1304.6	993.275
7b	13.5	1363.9	1067.4
6a	16.2	1571.45	1145.525
8b	24.3	1897.6	1393.15
7a	27	2001.375	1556.625
9b	40.50	2386.825	1882.775
8a	48.6	2594.375	2134.8
10b	72.9	3142.9	2683.325
9a	81.0	3305.975	2890.875
11b	121.5	3824.85	3305.975
10a	145.8	4136.175	3602.475
12b	218.7	4818.125	4091.7
11a	243.0	5055.325	4313.925
12a	437.4	5544.55	

TABLE 4-28:

Continuous Shear Rheometry Data of Cream Base No. 24.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	370.625	237.2
2b	0.9	385.45	237.2
1a	1.0	415.1	252.025
3b	1.5	474.4	266.85
2a	1.8	504.05	266.85
4b	2.7	593	326.15
3a	3.0	711.6	355.8
5b	4.5	1008.1	474.4
4a	5.4	1171.175	533.7
6b	8.1	1615.925	652.3
5a	9.0	1956.9	815.525
7b	13.5	2031.025	904.325
6a	16.2	2149.625	1022.925
8b	24.3	2386.825	1274.95
7a	27	2490.6	1408.425
9b	40.50	2742.625	1808.65
8a	48.6	2920.525	1942.075
10b	72.9	3320.8	2372
9a	81.0	3483.875	2505.425
11b	121.5	3987.929	2876.05
10a	145.8	4121.35	3068.775
12b	218.7	4417.85	3498.7
11a	283.0	4491.975	3602.475
12a	437.4	4832.95	

TABLE 4-29:

Continuous Shear Rheometry Data of Cream Base No. 25.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	148.25	88.95
2b	0.9	385.45	88.95
1a	1.0	415.1	88.95
3b	1.5	474.4	88.95
2a	1.8	504.05	88.95
4b	2.7	563.35	103.775
3a	3.0	607.825	103.775
5b	4.5	859.85	118.6
4a	5.4	919.15	118.6
6b	8.1	1037.75	148.25
5a	9.0	1171.175	192.725
7b	13.5	1260.125	237.2
6a	16.2	1319.425	266.85
8b	24.3	1497.325	355.8
7a	27	1512.15	385.45
9b	40.50	1719.7	533.7
8a	48.6	1823.475	593
10b	72.9	2105.15	800.55
9a	81.0	2194.1	830.8
11b	121.5	2075.5	1052.575
10a	145.8	2134.8	1171.175
12b	218.7	2268.225	1645.575
11a	243.0	2357.175	1764.175
12a	437.4	2638.85	

TABLE 4-30:

Continuous Shear Rheometry Data of Cream Base No. 26.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	785.725	489.225
2b	0.9	815.375	504.05
1a	1.0	845.025	533.7
3b	1.5	919.15	533.7
2a	1.8	948.8	563.35
4b	2.7	1097.05	563.35
3a	3.0	1126.7	593
5b	4.5	1186	622.65
4a	5.4	1304.6	622.65
6b	8.1	1601.1	741.25
5a	9.0	1660.4	830.2
7b	13.5	1764.175	918.8
6a	16.2	1897.6	1052.575
8b	24.3	2134.8	1349.075
7a	27	2238.575	1482.5
9b	40.50	2653.675	1882.775
8a	48.6	2831.575	2016.2
10b	72.9	3320.8	2372
9a	81.0	3543.175	2475.775
11b	121.5	4136.175	2965
10a	145.8	4343.725	3202.2
12b	218.7	5114.625	3928.625
11a	243.0	5203.575	4180.65
12a	437.4	5617.975	

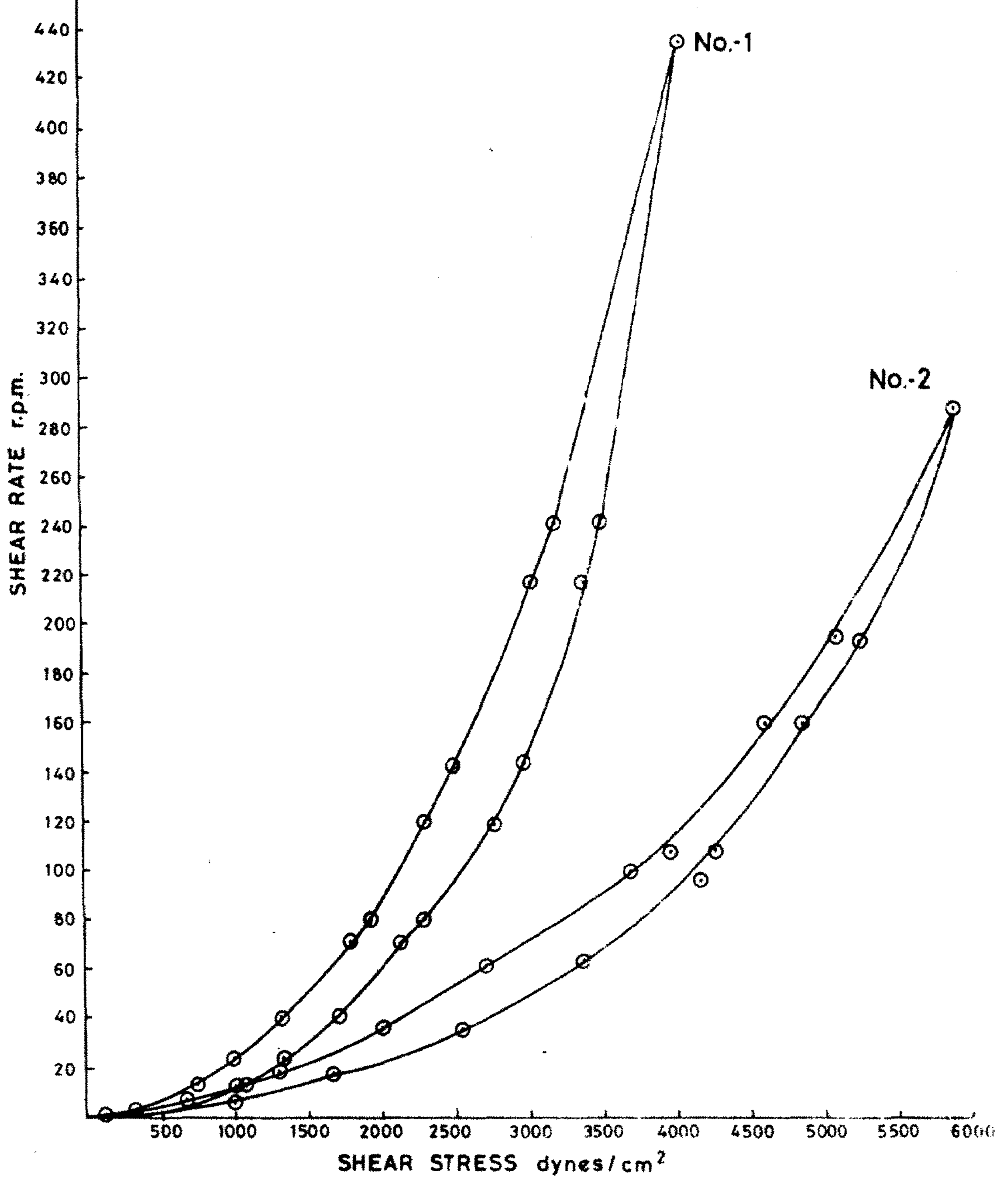
TABLE 4-31:

Continuous Shear Rheometry Data of Cream Base No. 27.

Speed	Shear rate r.p.m	Average of shear stress U.C. dynes/cm^2	Average of shear stress D.C. dynes/cm^2
1b	0.5	578.175	296.5
2b	0.9	622.65	326.15
1a	1.0	667.125	326.15
3b	1.5	726.425	355.8
2a	1.8	741.25	355.8
4b	2.7	770.4	385.45
3a	3.0	830.2	385.45
5b	4.5	889.5	385.45
4a	5.4	963.625	415.1
6b	8.1	1037.75	533.7
5a	9.0	1215.65	578.175
7b	13.5	1334.25	622.65
6a	16.2	1349.075	741.25
8b	24.3	1586.275	948.8
7a	27	1615.925	1022.925
9b	40.50	2060.675	1349.075
8a	48.6	2237.075	1527.325
10b	72.9	2668.5	1888.425
9a	81.0	2846.4	2001.375
11b	121.5	3394.925	2535.075
10a	145.8	3661.775	2727.8
12b	218.7	4299.25	3500
11a	243.0	4447.5	3691.425
12a	437.4	5010.85	

FIG. 4-1

RHEOGRAMS OF THE CREAM BASES No.-1 & No.-2



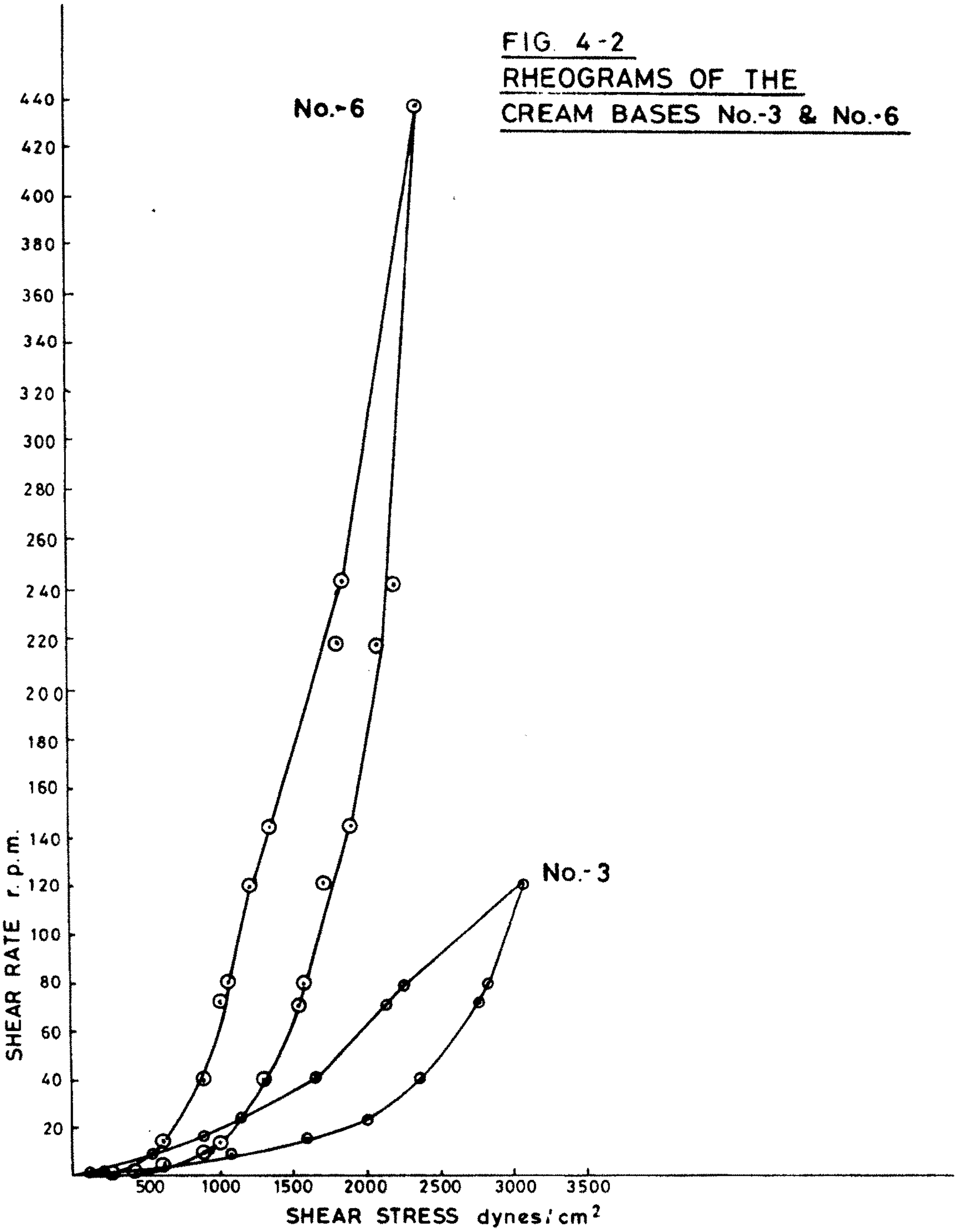


FIG. 4-2
RHEOGRAMS OF THE
CREAM BASES No.-3 & No.-6

FIG. 4-3
RHEOGRAM OF THE CREAM BASE No. 4

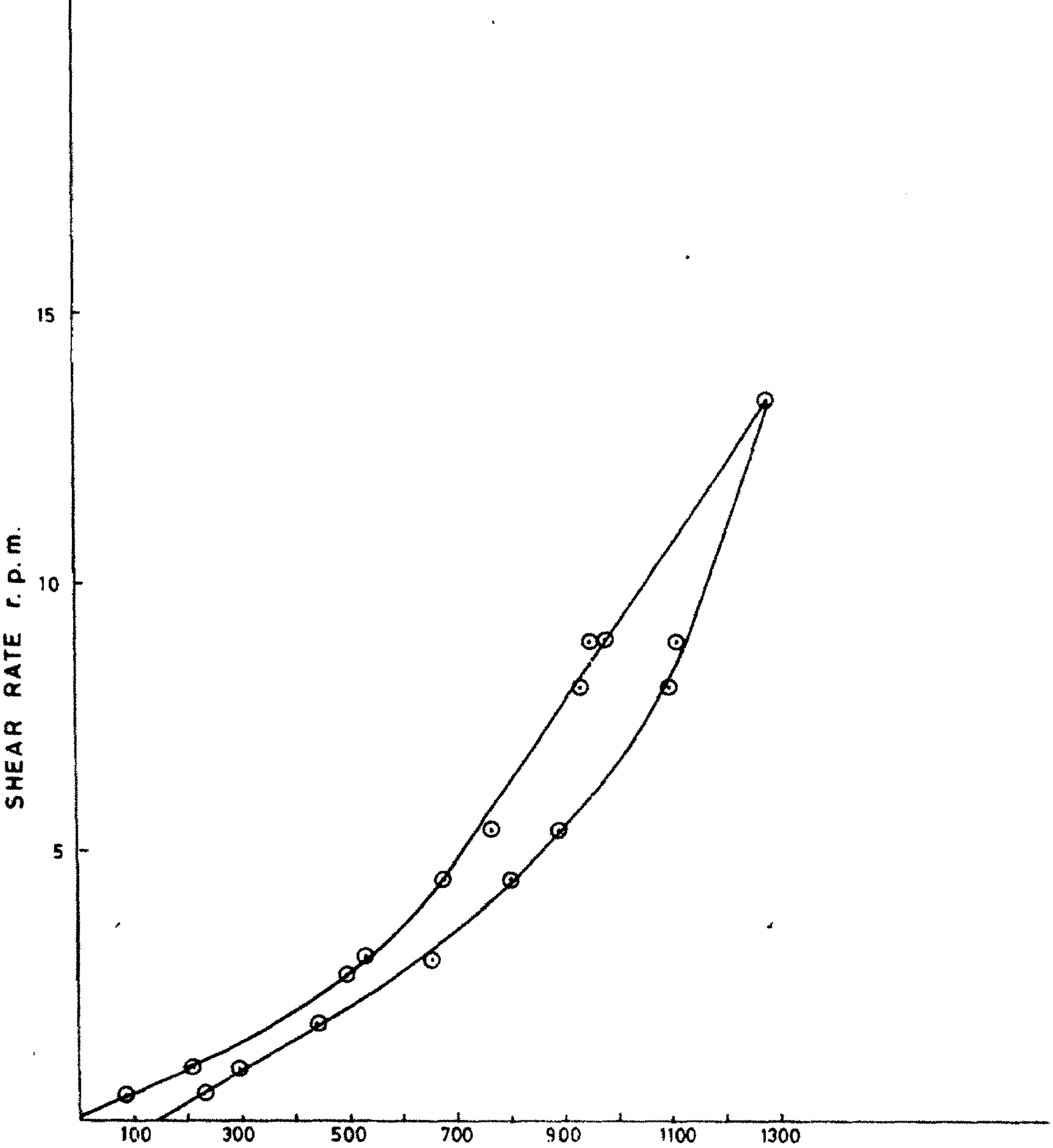


FIG. 4-4

RHEOGRAM OF THE CREAM BASE No.-5

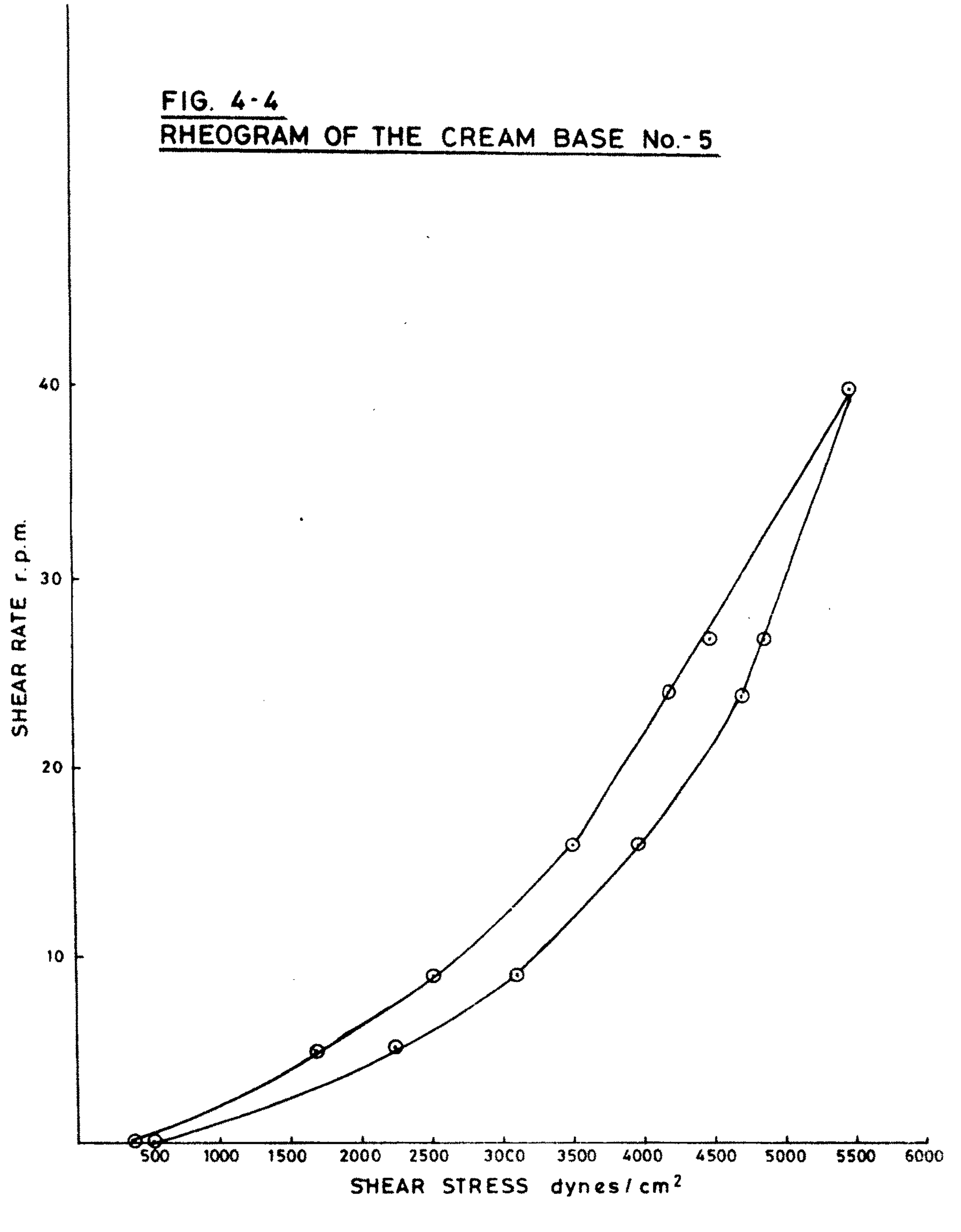


FIG. 4-5

RHEOGRAM OF THE CREAM BASE No.-8

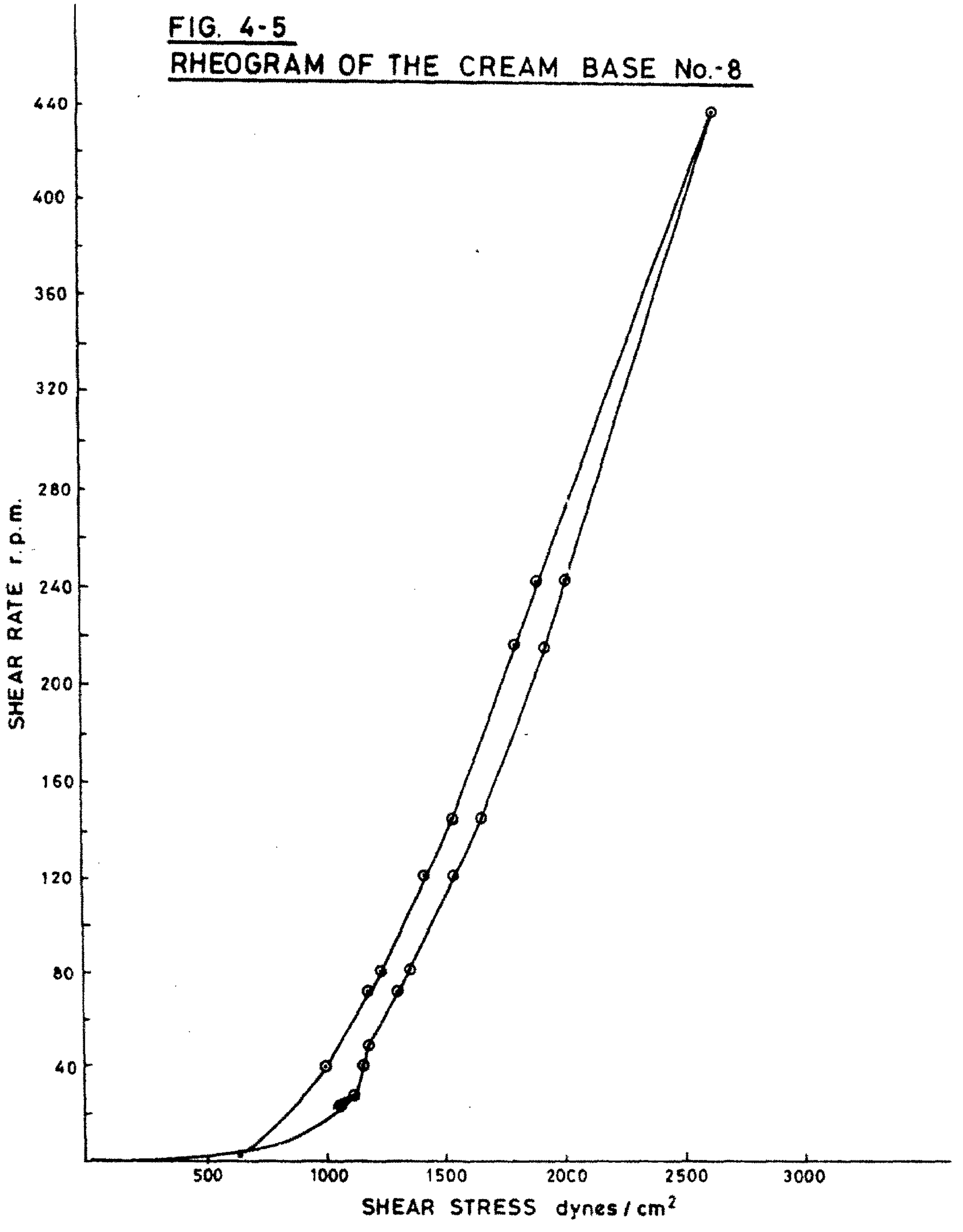
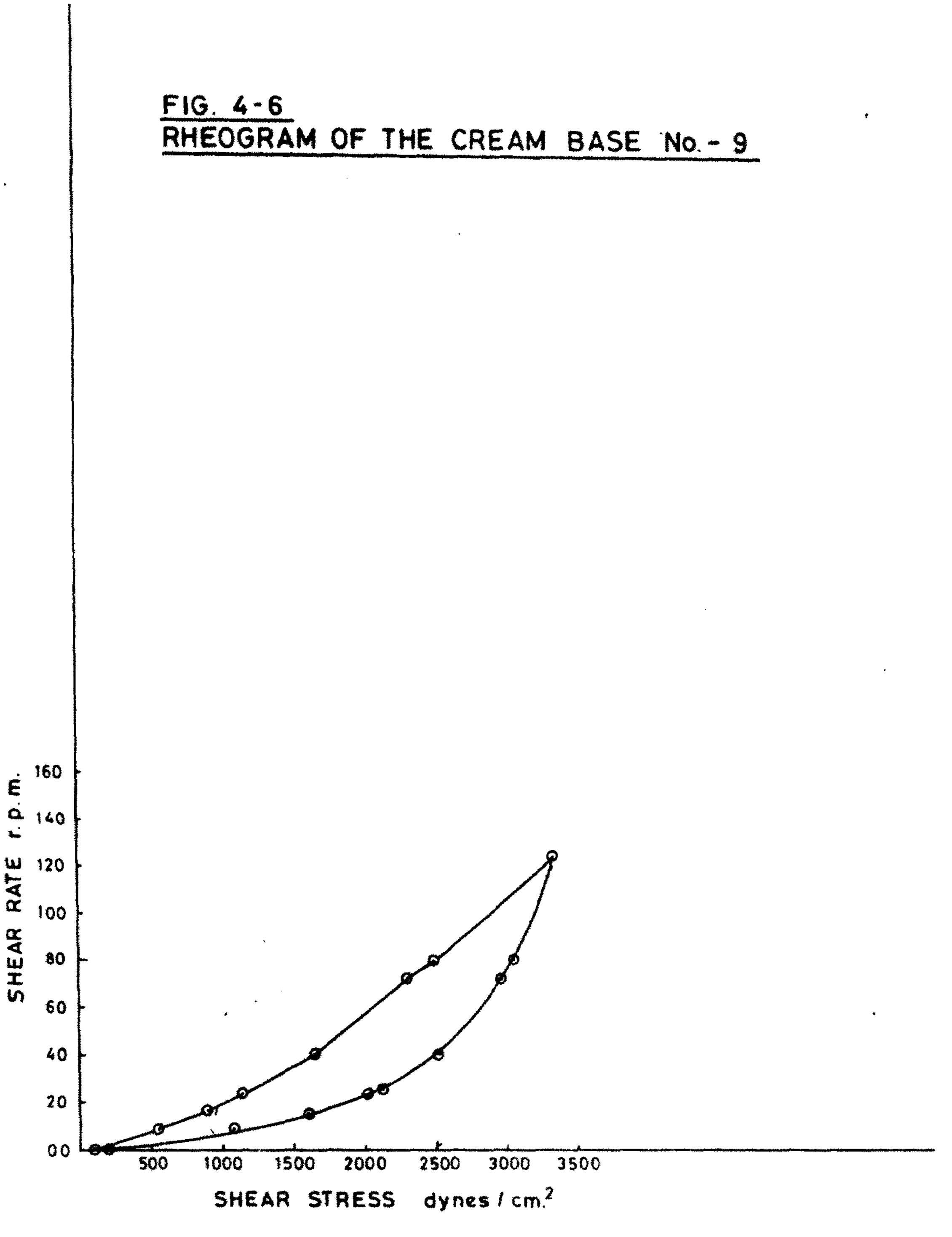


FIG. 4-6

RHEOGRAM OF THE CREAM BASE No. - 9



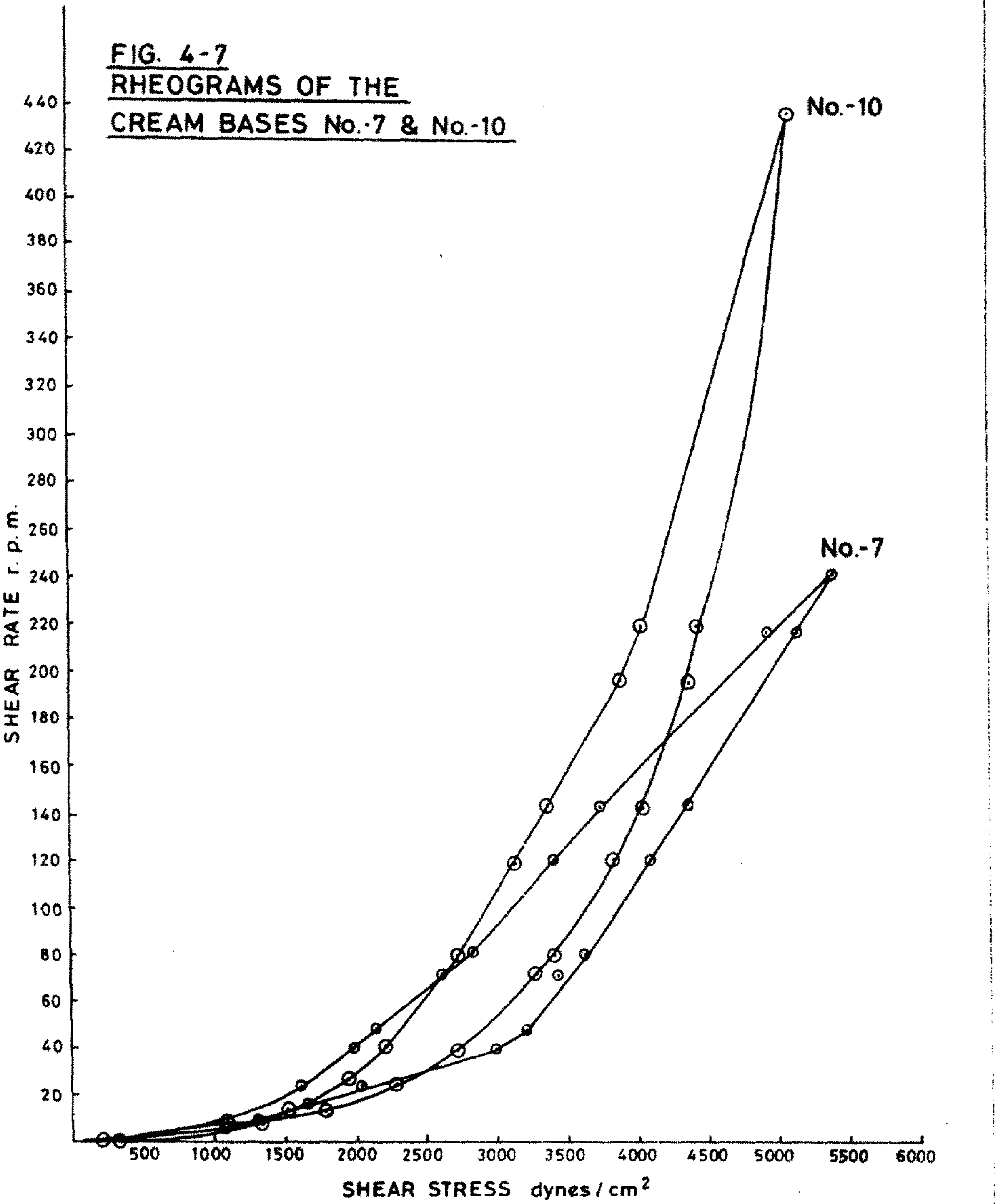


FIG. 4-7
RHEOGRAMS OF THE
CREAM BASES No.-7 & No.-10
No.-10
No.-7
SHEAR RATE r.p.m.
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
SHEAR STRESS dynes/cm²

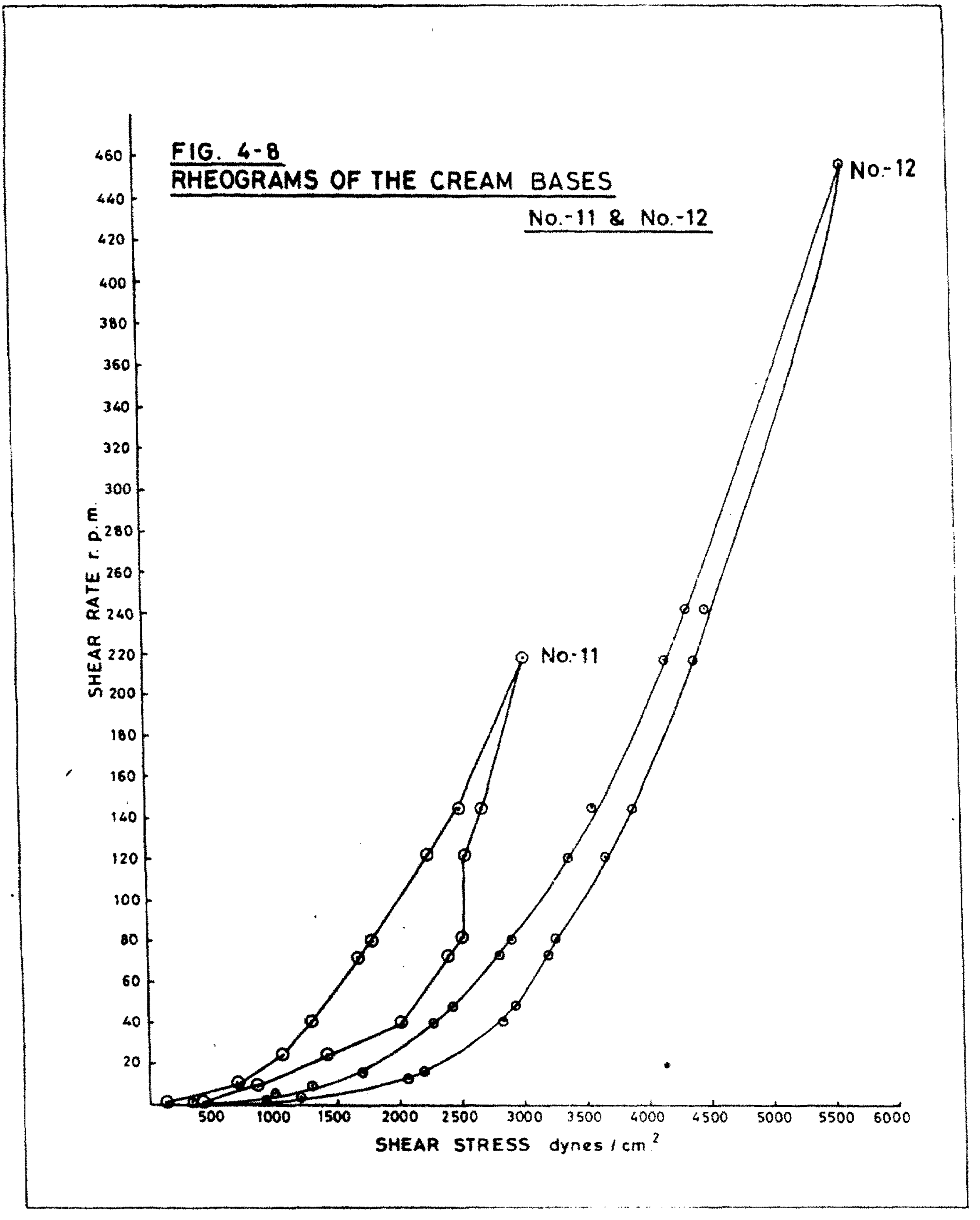


FIG. 4-8
RHEOGRAMS OF THE CREAM BASES
No.-11 & No.-12
No.-12
No.-11
SHEAR RATE r.p.m.
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
SHEAR STRESS dynes / cm 2

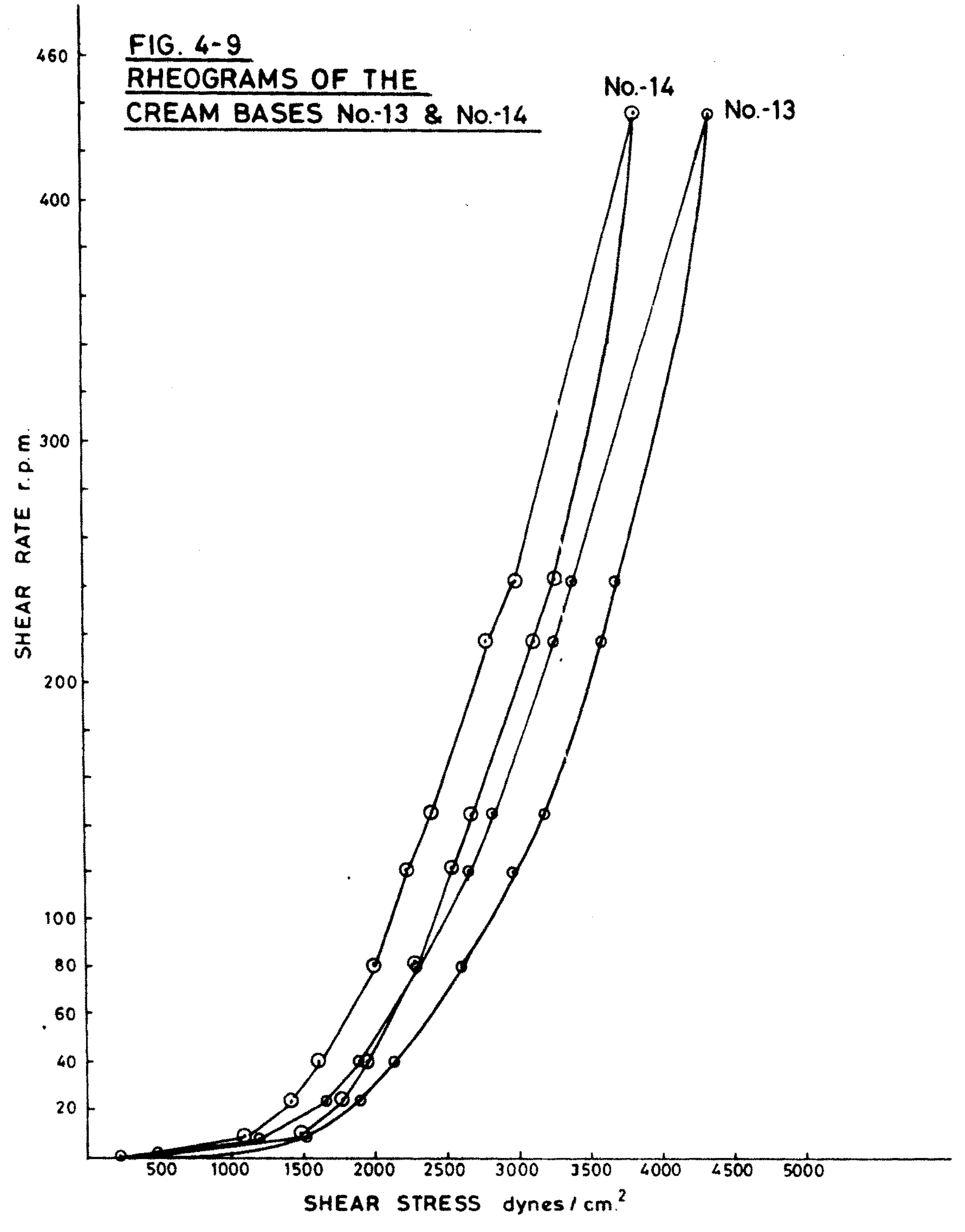


FIG. 4-9
RHEOGRAMS OF THE
CREAM BASES No.-13 & No.-14
No.-14
No.-13
SHEAR RATE r.p.m.
460
400
300
200
100
80
60
40
20
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
SHEAR STRESS dynes / cm.2

FIG. 4-10

RHEOGRAMS OF THE CREAM BASES No.-15 & No.-17

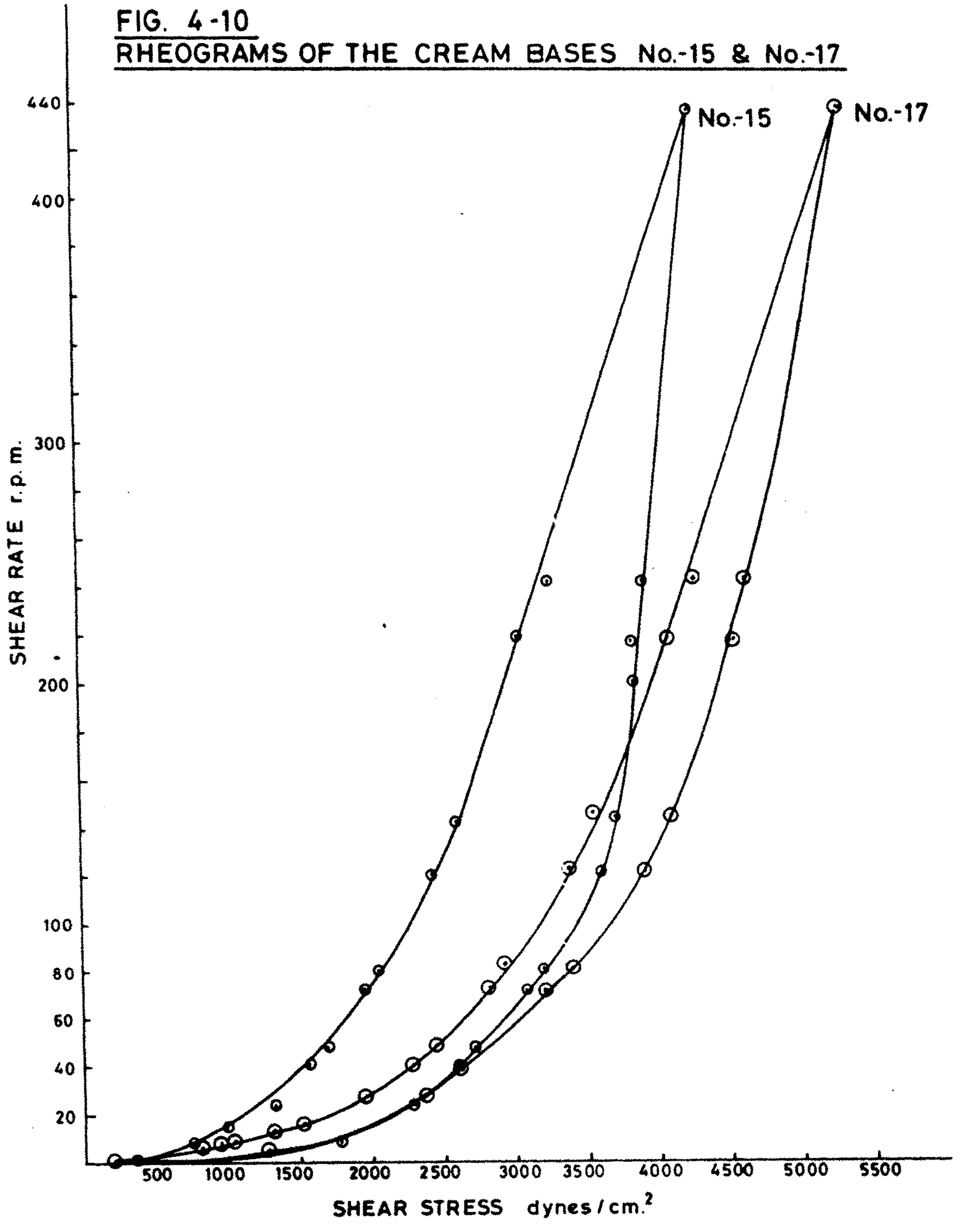
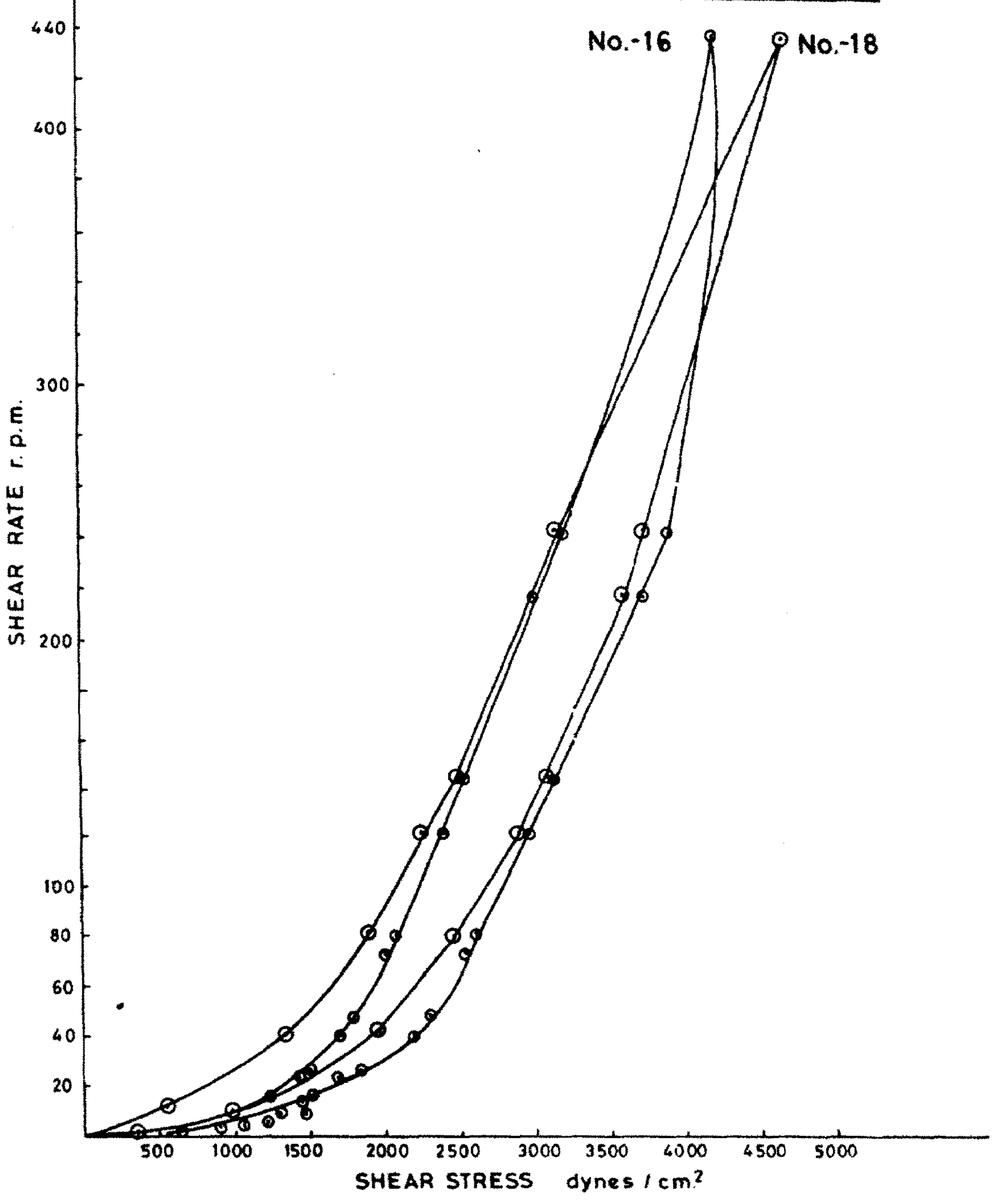


FIG. 4-11

RHEOGRAMS OF THE CREAM BASES No.-16 & No.-18



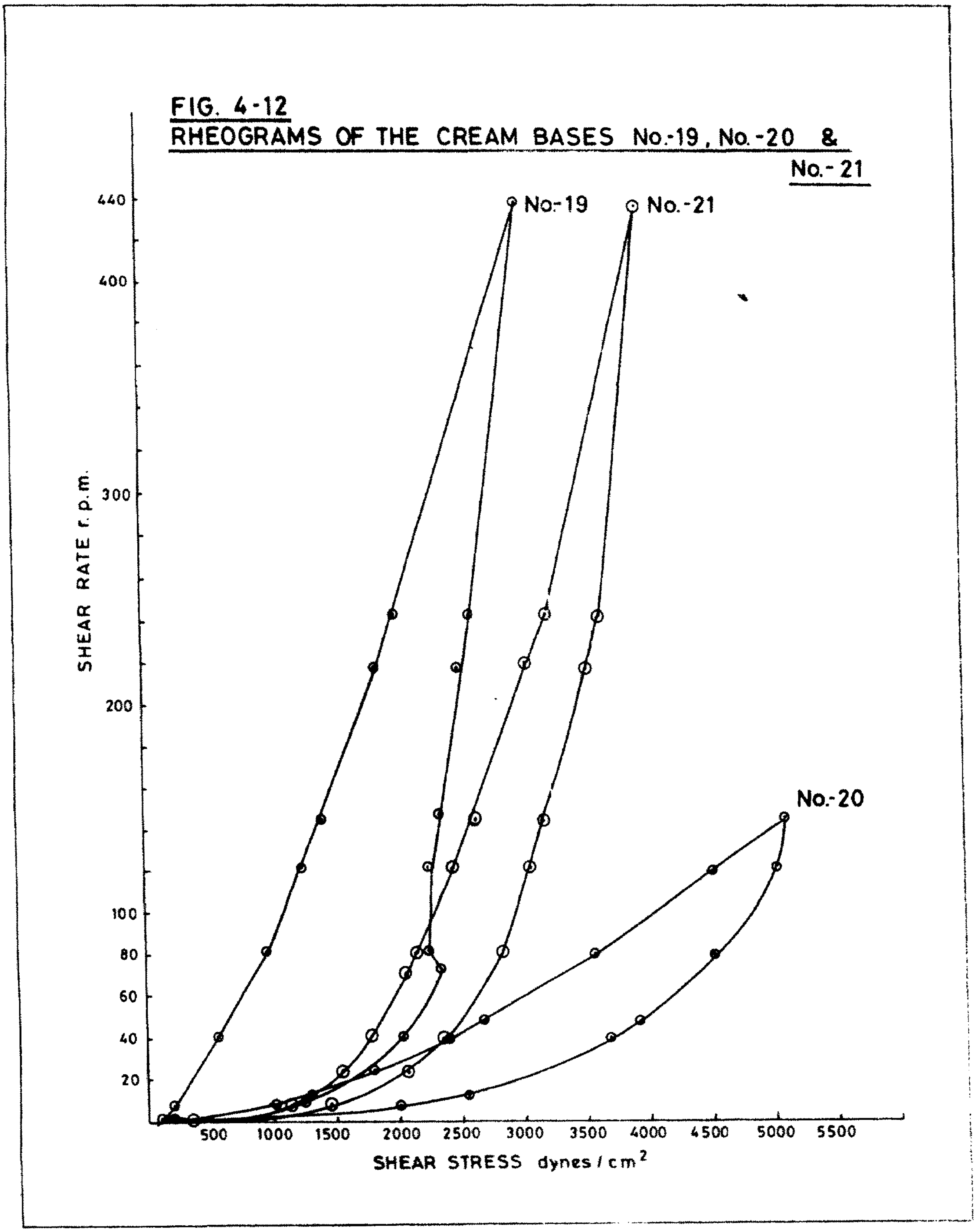


FIG. 4-12
RHEOGRAMS OF THE CREAM BASES No.-19, No.-20 & No.-21
No.-19
No.-21
No.-20
SHEAR RATE r.p.m.
440
400
300
200
100
80
60
40
20
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
SHEAR STRESS dynes/cm²

FIG. 4-13

RHEOGRAMS OF THE CREAM BASES No.-22, No.-23 & No.-24

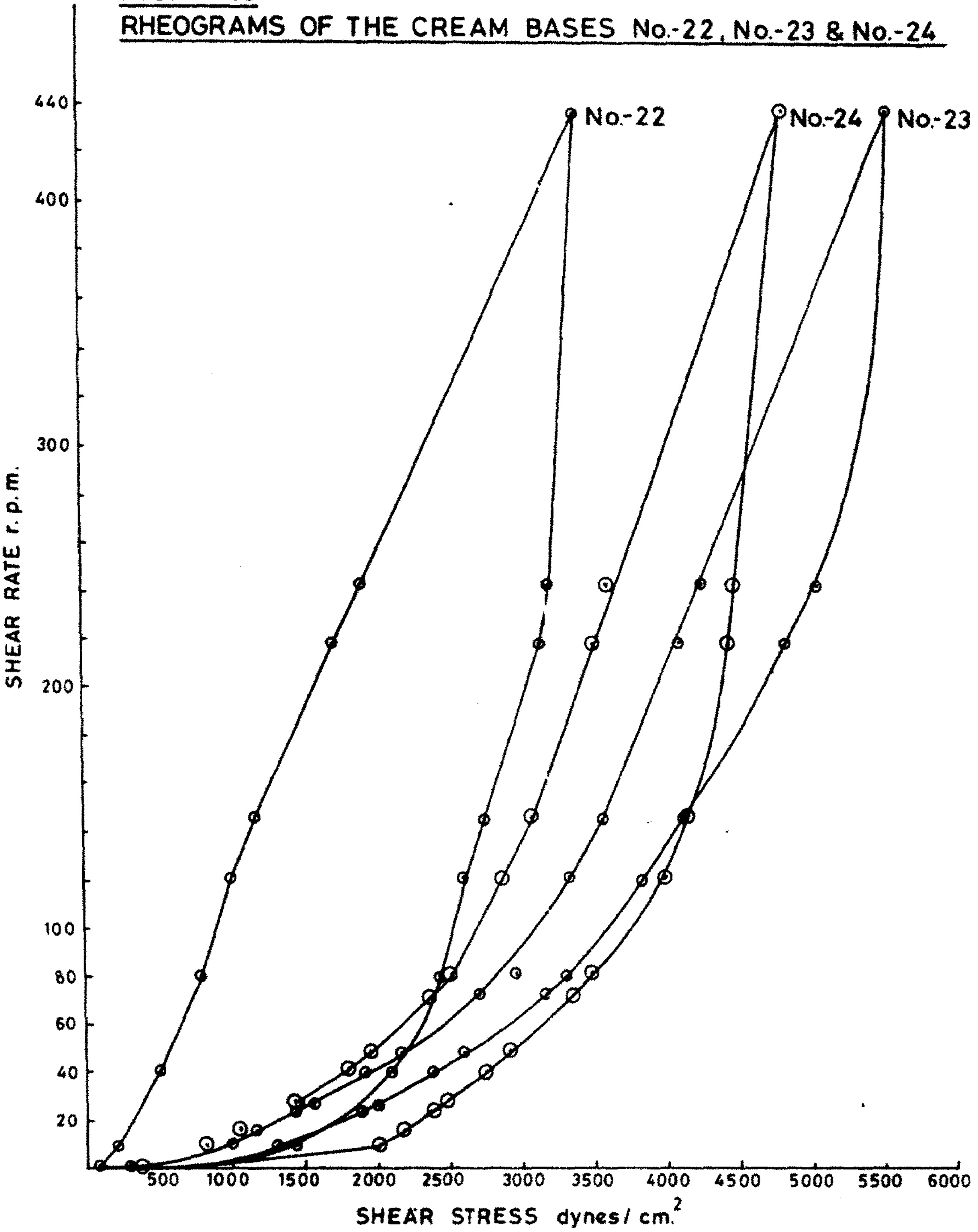
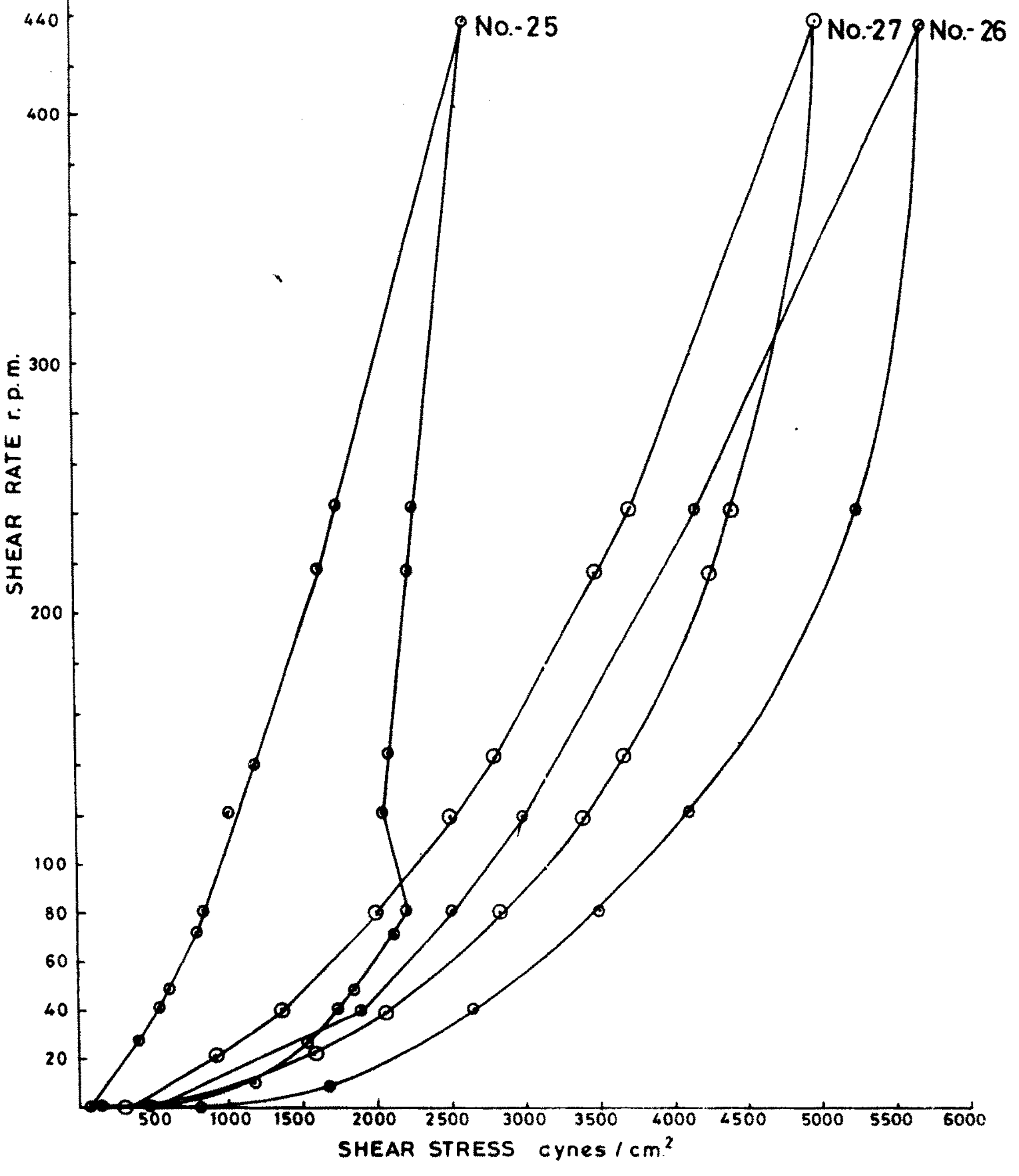


FIG. 4-14

RHEOGRAMS OF THE CREAM BASES No:-25, No.-26 & No.-27



been destroyed by the shear stress used.

The three parameter apparent viscosity at the top, yield value and the area of the hysteresis loop are considered to be necessary and sufficient for the description of the thixotropy and plastic flow.

The area of the hysteresis loop was determined by drawing on a paper, cutting out and weighing.

Thus the rheologically evaluated promising bases were selected and the formule of the selected bases are recorded in Table 4-32 and the composite data of above bases are recorded in Table 4-33. Thus the rheologically evaluated promising bases subsequently used in the *in vitro* medicament release experiments.

3.6. Results and Discussion

One hundred and ten hydrophilic cream bases were prepared using the different concentration of commonly used ingredients. The formulae of all the bases recorded in Table 4-1. First screening evaluation was based on the following desirable characteristics.

(1) Grainy :
Grainy particles observed when base spreaded on the back of the hand or rubbed between thumb and the first finger.

(2) Separation :
Separation of either oil or water was observed.

(3) Satisfactory :
Physically stable, visual appearance, smooth cream.

(4) Unsatisfactory :

Any one of the following things was observed.

(a) Too thin consistancy.

(b) Colour development.

(c) Separation of oil and water within two weeks of manufacturing date.

After first screening evaluation, seventy one selected cream bases were subjected to second screening evaluation in which the pH, spreadability, water washability were checked initially and after one month storage at different conditions (AC, R.T., 37° and 42° at 80% RH) and the data recorded in Table 4-2. After second screening evaluation sixty selected cream bases were subjected to third screening evaluation in which consistency, penetration and spreadability of the cream bases were checked and data recorded in Tables 4-3 and 4-4. After third screening evaluation thirty four selected cream bases were subjected to rheological studies in which all the cream bases indicate non-Newtonian flow characteristics as no part of the rheogram is linear, hence the viscosity cannot be expressed by a single value, as is the case with Newtonian fluids. As such a determination corresponds to a single point on the curve and would not give a correct picture about the nature of the substance exhibited pseudoplastic flow behaviour. Unlike Bingham - bodies such bases exhibit no yield value, but instead are characterised by rheograms which approach the origin or nearer to the origin of the graph as in case of Newtonian liquids. However, unlike the linear curve for Newtonian materials the pseudoplastic flow curve was non linear. In these cases the shear stress did not increase linearly with the shear rate, hence the viscosity did not remain constant at different rate of shear. The single point determinations for the two pseudoplastic bases could nearly be the same even though rheograms for these two bases could have markedly different curvatures. The viscosity of pseudoplastic substance decreases with increasing rate of shear. In such cases comparing viscosities becomes difficult, because depending on the points on curve selected for determination entirely different conclusions are likely to be reached.

Apparent viscosities of cream bases may be obtained at any rate of shear from the slope of the tangent drawn to the curve at any specified point. However, the most satisfactory representation of pseudoplastic materials of this type is probably the whole graphical plot of the entire consistancy curve.

The curved rheograms for a pseudoplastic material result from a shearing action on the long chained molecules or other complex structures of the material which are disarranged and matted together at rest and remain so at low shear rates, but which tend to become aligned at higher rate of shear. The materials used for the preparation of the cream bases form a suitable physical structure which is likely to be responsible for pseudoplasticity. Some of the solvents associated with the molecules may also be excluded as the particles align and the resistance of the effectively smaller particles to flow is reduced to some extent[9]. Hence such systems, are referred to as 'shear rate thinning'.

It was observed from all the rheograms that the up curves and the down curves for all the bases could not be superimposed. This was probably because the dispersions were broken down and the consistancy was reduced as exhibited by down curve. This property of semisolids is termed as thixotrophy and may be described as a reversible isothermal sol-gel transformation. Following the break down of the structure by the increase of shearing stress, a period of time is required to elapse, before fluid recovers its original consistancy.

This is the main reason as to why the up curves and down curves shown in figures did not coincide, but instead formed a loop of hysterisis. The loops formed by the up-curves and down-curves of thixotropic materials result from a gel like structure which is broken down as the material is agitated. In this region of shear the structure is apparently in the process of reforming, just as it is when the material is allowed to stand undisturbed.[10]

These above parameters have clearly defined the thixotropy and plasticity of the system.

The plasticity of a system is associated with the presence of flocculated particles in the concentrated suspension. As a result, a continuous structure is set up throughout the system. The yield value is present because of the contacts between adjacent particles which must be broken down before flow to occur, consequently the yield value is an indicative of the force of flocculation. Frictional forces between the moving particles can also contribute to the yield value. As the yield value is exceeded any further increase in shearing stress brings about a directly proportional increase in shear rate.

Thixotropy may be said to be due to the presence of assymetric particles which, through numerous points of contact, set up a loose three dimensional network throughout the sample. At rest, the structure confers some degree of rigidity on the system. As shear is applied and flow starts, the structure begins to break down as the points of contact are disrupted and the particles become aligned and the material undergoes gel-to-sol transformation, and exhibit shear thinning. Upon removal of the stress, the structure starts to reform, the process being not instantaneous; rather it is progressive restoration of consistancy as the assymetric particles come into contact with each other by undergoing random Brownian movement.

Continuous shear flow curves for cream bases were in the form of anticlockwise hysteresis loops. Typical curves after one month storage at 28±1° are shown in Figures 4-1 to 4-14 and recorded in tables 4-5 to 4-31. Formulae of twenty seven selected cream bases after rheological studies are recorded in Table 4-32 and the composite data of above bases are recorded in Table 4-33.

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